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(57) Abstract

Provided are methods and compositions for treating hepatitis virus infections in mammals, especially humans. The methods comprise (1) administering *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compounds alone or in combination with nucleoside antiviral agents, nucleotide antiviral agents, mixtures thereof, or immunomodulating/immunostimulating agents, or (2) administering *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compounds alone or in combination with nucleoside antiviral agents, nucleotide antiviral agents, or mixtures thereof, and immunomodulating/immunostimulating agents.

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USE OF *N*-SUBSTITUTED-1,5-DIDEOXY-1,5-IMINO-D-GLUCITOL COMPOUNDS FOR TREATING HEPATITIS VIRUS INFECTIONS

RELATED APPLICATION DATA

This application claims the benefit of priority of U.S. provisional application serial number 60/074,508, filed February 12, 1998. This application is also a continuation in part of U.S. application serial number 09/023,401, filed February 12, 1998. The contents of each of these applications is incorporated by reference herein in their entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to methods and compositions for treating hepatitis virus infections, especially hepatitis B virus infections, in mammals, especially humans. The methods comprise (1) administering *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compounds alone or in combination with nucleoside antiviral agents, nucleotide antiviral agents, mixtures thereof, or immunomodulating/-immunostimulating agents, or (2) administering *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compounds alone or in combination with nucleoside antiviral agents, nucleotide antiviral agents, or mixtures thereof, and immunomodulating/immunostimulating agents. Such combinations of anti-hepatitis viral agents show unexpected efficacy in inhibiting replication and secretion of hepatitis viruses in cells of mammals infected with these viruses.

Description of Related Art

Hepatitis Viruses

Hepatitis B Virus (HBV, HepB) is a causative agent of acute and chronic liver disease including liver fibrosis, cirrhosis, inflammatory liver disease, and hepatic cancer that can lead to death in some patients (Joklik, Wolfgang K., *Virology*, Third Edition, Appleton & Lange, Norwalk, Connecticut, 1988 (ISBN 0-8385-9462-X)). Although effective vaccines are available, there are still more than 300 million people worldwide,

i.e., 5% of the world's population, chronically infected with the virus (Locarnini, S. A., et. al., *Antiviral Chemistry & Chemotherapy* (1996) 7(2):53-64). Such vaccines have no therapeutic value for those already infected with the virus. In Europe and North America, between 0.1% to 1% of the population is infected. Estimates are that 15% to 20% of individuals who acquire the infection develop cirrhosis or another chronic disability from HBV infection. Once liver cirrhosis is established, morbidity and mortality are substantial, with about a 5-year patient survival period (Blume, H., E., et.al., *Advanced Drug Delivery Reviews* (1995) 17:321-331). It is therefore necessary and of high priority to find improved and effective anti-HBV anti-hepatitis therapies (Locarnini, S. A., et. al., *Antiviral Chemistry & Chemotherapy* (1996) 7(2): 53-64).

Other hepatitis viruses significant as agents of human disease include Hepatitis A, Hepatitis B, Hepatitis C, Hepatitis Delta, Hepatitis E, Hepatitis F, and Hepatitis G (Coates, J. A. V., et.al., *Exp. Opin. Ther. Patents* (1995) 5(8):747-756). In addition, there are animal hepatitis viruses that are species-specific. These include, for example, those infecting ducks, woodchucks, and mice.

1,5-dideoxy-1,5-imino-D-glucitol Compounds

1,5-dideoxy-1,5-imino-D-glucitol (also known as 1-deoxynojirimycin, DNJ) and its *N*-alkyl derivatives (together, "imino sugars") are known inhibitors of the *N*-linked oligosaccharide processing enzymes alpha glucosidase I and II (Saunier et al., *J. Biol. Chem.* (1982) 257:14155-14161 (1982); Elbein, *Ann. Rev. Biochem.* (1987) 56:497-534). As glucose analogs, they also have potential to inhibit glucose transport, glucosyl-transferases, and/or glycolipid synthesis (Newbrun et al., *Arch. Oral Biol.* (1983) 28: 516-536; Wang et al., *Tetrahedron Lett.* (1993) 34:403-406). Their inhibitory activity against glucosidases has led to the development of these compounds as anti-hyperglycemic agents and antiviral agents. See, for example, PCT International Publication WO 87/03903 and U.S. Patents 4,065,562; 4,182,767; 4,533,668; 4,639,436; 4,849,430; 4,957,926; 5,011,829; and 5,030,638.

Glucosidase inhibitors such as *N*-alkyl-1,5-dideoxy-1,5-imino-D-glucitol compounds wherein the alkyl group contains between three and six carbon atoms have been shown to be effective in the treatment of Hepatitis B infection (PCT International Publication WO 95/19172). For example, *N*-(n-butyl)-deoxynojirimycin (*N*-butyl-DNJ; *N*-(n-butyl)-1-5-dideoxy-1,5-imino-D-glucitol) is effective for this purpose (Block, T. M., *Proc. Natl. Acad. Sci. USA* (1994) 91:2235-2239; Ganem, B. *Chemtracts: Organic Chemistry* (1994) 7(2), 106-107). *N*-butyl-DNJ has also been tested as an anti-HIV-1 agent in HIV infected patients, and is known to be well tolerated. Another alpha glucosidase inhibitor, deoxynojirimycin (DNJ), has been suggested as an antiviral agent for use in combination with *N*-(phosphonoacetyl)-L-aspartic acid (PALA) (WO 93/18763). However, combinations of *N*-substituted-imino-D-glucitol derivatives and other antiviral agents for the treatment of hepatitis virus infections have not been previously disclosed or suggested. From results obtained in a woodchuck animal model of hepatitis virus infection, Block et al. ((1998) *Nature Medicine* 4(5):610-614) suggested that glucosidase inhibitors such as *N*-nonyl DNJ, which interfere with specific steps in the N-linked glycosylation pathway of hepatitis virus glycoproteins, may be useful in targeting glycosylation processing as a therapeutic intervention for hepatitis B virus.

Nucleoside and Nucleotide Antiviral Agents

Reverse transcriptase inhibitors, including the class of nucleoside and nucleotide analogs, were first developed as drugs for the treatment of retroviruses such as human immunodeficiency virus (HIV), the causative agent of AIDS. Increasingly, these compounds have found use against other viruses, including both RNA and DNA viruses, via viral screening and chemical modification strategies. Nucleoside and nucleotide analogs exert their antiviral activities by inhibiting the corresponding DNA and RNA polymerases responsible for synthesis of viral DNA and RNA, respectively. Because viruses contain different forms of polymerases, the same nucleoside/nucleotide compound can have a dramatically different effect against different viruses. For example, lamivudine (3TC™) appears to be useful against HBV infection, whereas zidovudine

(AZT™) appears to have little use against the same virus (Gish, R.G., et al., *Exp. Opin. Invest. Drugs* (1995) 4(2):95-115).

Toxicity has been significant with some nucleoside analog antivirals. For example, clinical tests on the use of the nucleoside analog fialuridine (FIAU) for treatment of chronic hepatitis B were suspended recently due to drug-related liver failure leading to death in some patients. Consequently, there is still a need for safer drug regimens for the treatment of hepatitis B infections and hepatitis (Mutchnick, M. G., et. al., *Antiviral Research* (1994) 24:245-257).

Immunomodulators and Immunostimulants

Immunomodulators/immunostimulators such as interferon alfa and other cytokines have been used for the treatment of HBV infection with promising results. Unfortunately, the response rates are lower than desired. Interferon treatment is currently approved by the FDA for the treatment of Hepatitis B. Other immune system-affecting drug candidates are presently being investigated. These include thymic peptides for use in the treatment of chronic hepatitis B (CHB), isoprinosine, steroids, Shiff base-forming salicylaldehyde derivatives such as Tucaresol, levamisol, and the like (Gish, R. G., et.al., *Exp. Opin. Invest. Drugs* (1995) 4(2):95-115; Coates, J.A.V., et.al., *Exp. Opin. Ther. Patents* (1995) 5(8):747-765).

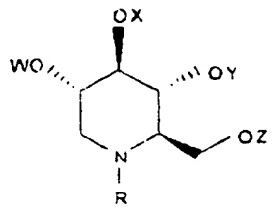
SUMMARY OF THE INVENTION

As noted above, the use of the *N*-substituted-imino-D-glucitol compounds and derivatives thereof disclosed herein alone, or in combination with other anti-hepatitis virus compounds has, to the present inventor's knowledge, neither been suggested nor disclosed. The use of two or more anti-viral agents to provide improved therapy for the treatment of hepatitis B virus infections is desirable due to the morbidity and mortality of the disease. Combination therapy is also desirable since it should reduce toxicity in patients as it enables the physician to administer lower doses of one or more of the drugs being given to a patient. Combination therapy can also help to prevent the development

of drug resistance in patients (Wiltink, E. H. H., *Pharmaceutish Weekblads Scientific Edition* (1992) 14(4A):268-274). The result of an improved efficacy configuration combined with a relative lack of toxicity and development of resistance would provide a much improved drug treatment profile.

The present inventors have surprisingly discovered that the use of the *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compounds disclosed herein are effective in treating hepatitis virus infections. Furthermore, the use of these compounds in combination with nucleoside or nucleotide antiviral compounds, or combinations thereof, and/or immunomodulators/immunostimulants, results in unexpectedly greater anti-hepatitis virus effectiveness of the compounds compared to the combined antiviral activities expected of the individual compounds alone. Whether this is due to different mechanisms of action of the different classes of drugs employed or some other biological phenomenon is presently unclear.

Accordingly, in a first aspect, the present invention provides a method for treating a hepatitis virus infection in a mammal, comprising administering to said mammal an anti-hepatitis virus effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof:



(I)

wherein R is selected from the group consisting of straight chain alkyl having a chain length of C_7 to C_{20}, branched chain alkyl having a chain length of C_3 to C_{20} in the main chain, alkoxyalkyl, arylalkyl, and cycloalkylalkyl, and wherein W, X, Y and Z are each

independently selected from the group consisting of hydrogen, alkanoyl, aroyl, and trifluoroalkanoyl.

In a second aspect, the present invention provides a method for treating a hepatitis virus infection in a mammal, comprising administering to said mammal an antiviral composition comprising an antiviral effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof, as above.

In a third aspect, the present invention provides a method for treating a hepatitis virus infection in a mammal, comprising administering to said mammal an antiviral composition consisting essentially of an antiviral effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof, as above.

In a fourth aspect, the present invention provides a method for treating a hepatitis virus infection in a mammal, consisting essentially of administering to said mammal an antiviral effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof, as above.

In a fifth aspect, the present invention provides a method for treating a hepatitis virus infection in a mammal, consisting essentially of administering to said mammal an antiviral effective amount of an antiviral compound consisting essentially of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof, as above.

In a sixth aspect, the present invention provides a method for treating a hepatitis virus infection in a mammal, consisting essentially of administering to said mammal a first amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof, as above, and a second amount of an antiviral compound selected from the group consisting of a nucleoside antiviral compound, a nucleotide antiviral compound, an immunomodulator, an immunostimulant, and mixtures thereof, wherein said first and second amounts of said compounds together comprise an anti-hepatitis virus effective amount of said compounds.

In another aspect, the present invention provides a method for treating a hepatitis B virus infection in a mammal, comprising administering to said mammal from about 0.1 mg/kg/day to about 100 mg/kg/day of at least one N-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof, as above, and from about 0.1 mg/person/day to about 500 mg/person/day of a compound selected from the group consisting of a nucleoside antiviral compound, a nucleotide antiviral compound, and a mixture thereof.

In another aspect, the present invention provides a method for treating a hepatitis B virus infection in a human patient, comprising administering to said human patient from about 0.1 mg/kg/day to about 100 mg/kg/day of an *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound selected from the group consisting *N*-(n-nonyl-)-1,5-dideoxy-1,5-imino-D-glucitol or a pharmaceutically acceptable salt thereof, *N*-(n-nonyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate or a pharmaceutically acceptable salt thereof, and mixtures thereof, and from about 0.1 mg/person/day to about 500 mg/person/day of (-)-2'-deoxy-3'-thiocytidine-5'-triphosphate.

In another aspect, the present invention provides a method for treating a hepatitis virus infection in a mammal, comprising administering to said mammal an antiviral effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof, as above, substantially exclusive of the administration of an antiviral composition comprising a nucleoside, a nucleotide, an immunomodulator, or an immunostimulant.

In another aspect, the present invention provides a method for treating a hepatitis virus infection in a mammal, comprising administering to said mammal an antiviral effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof, as above, substantially exclusive of the administration of antiviral compounds other than compounds of Formula I.

In another aspect, the present invention provides a pharmaceutical composition, comprising an antiviral effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof, as above, and a pharmaceutically acceptable carrier, excipient,or diluent.

In another aspect, the present invention provides a pharmaceutical composition, consisting essentially of an antiviral effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof, as above, and a pharmaceutically acceptable carrier, diluent, or excipient.

In another aspect, the present invention provides a pharmaceutical composition, comprising an antiviral effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof, as above, substantially free of a nucleoside, nucleotide, immunomodulator, or immunostimulant, and a pharmaceutically acceptable, carrier, diluent, or excipient.

In another aspect, the present invention provides a pharmaceutical composition, comprising an antiviral effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof, as above, substantially free of antiviral compounds other than compounds of Formula I, and a pharmaceutically acceptable, carrier, diluent, or excipient.

In yet another aspect, the present invention provides a composition, comprising at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof, as above, and an antiviral compound selected from the group consisting of a nucleoside antiviral compound, a nucleotide antiviral compound, an immunomodulator, an immunostimulant, and mixtures thereof.

In another aspect, the present invention provides a pharmaceutical composition, comprising a first amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof, as above; a second amount of an antiviral compound selected from the group consisting of a nucleoside antiviral compound, a nucleotide antiviral compound, an immunomodulator, an

immunostimulant, and mixtures thereof; and a pharmaceutically acceptable carrier, diluent, or excipient, wherein said first and second amounts of said compounds together comprise an antiviral effective amount of said compounds.

In a further aspect, the present invention provides a pharmaceutical composition for treating a hepatitis B virus infection in a mammal, comprising from about 0.1 mg to about 100 mg of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof, as above; from about 0.1 mg to about 500 mg of a compound selected from the group consisting of a nucleoside antiviral compound, a nucleotide antiviral, and mixtures thereof; and a pharmaceutically acceptable carrier, diluent, or excipient.

In another aspect, the present invention provides a pharmaceutical composition for treating a hepatitis B virus infection in a human patient, comprising from about 0.1 mg to about 100 mg of an *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound selected from the group consisting of *N*-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol or a pharmaceutically acceptable salt thereof, *N*-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate or a pharmaceutically acceptable salt thereof, and mixtures thereof; from about 0.1 mg to about 500 mg of (-)-2'-deoxy-3'-thiocytidine-5'-triphosphate; and a pharmaceutically acceptable carrier, diluent, or excipient.

In yet another aspect, the present invention provides a salt, comprising an *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I, as above, and a compound selected from the group consisting of a nucleoside having an acidic moiety and a nucleotide.

In a further aspect, the present invention provides a method, comprising reacting *N*-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol and (-)-2'-deoxy-3'-thiocytidine-5'-triphosphate under salt-forming conditions, as well as a salt produced thereby.

Further scope of the applicability of the present invention will become apparent from the detailed description and drawings provided below. However, it should be understood that the following detailed description and examples, while indicating preferred embodiments of the invention, are given by way of illustration only since

various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features, and advantages of the present invention will be better understood from the following detailed description taken in conjunction with the accompanying drawings, all of which are given by way of illustration only, and are not limitative of the present invention, in which:

Figure 1 shows the anti-hepatitis B virus activity of (-)-2'-deoxy-3'-thiocytidine-5'-triphosphate (3TC) alone and in combination with *N*-nonyl-DNJ *in vitro*.

Figure 2 shows the plasma concentration of *N*-nonyl-DNJ versus dose of *N*-nonyl-DNJ for each animal in Example 5, from samples taken during dosing. Animals are indicated by unique letters, and a small amount of random noise has been added to the dose value so that overlapping values can be distinguished.

Figure 3 shows the slope of Log(IPDNA + 10) to week versus dose. A distinct letter is used for each animal. The fitted line is from a four parameter logistic model. The parameters of the fitted curve and their approximate standard errors are shown on the plot.

DETAILED DESCRIPTION OF THE INVENTION

The following detailed description is provided to aid those skilled in the art in practicing the present invention. Even so, this detailed description should not be construed to unduly limit the present invention as modifications and variations in the embodiments discussed herein can be made by those of ordinary skill in the art without departing from the spirit or scope of the present inventive discovery.

The contents of each of the patent documents and other references cited herein, including the contents of the references cited within these primary references, are herein incorporated by reference in their entirety

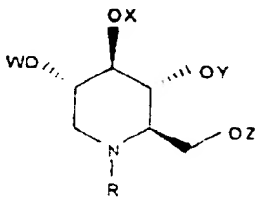
The present inventors have discovered that the use of *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compounds are effective when used alone for treating hepatitis virus infections. They have additionally discovered that combinations of *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compounds with anti-hepatitis virus nucleosides or nucleotides, and/or immunomodulators/immunostimulants, are also effective for this purpose. There is some evidence that certain combinations may be more effective in inhibiting hepatitis virus replication than would have been expected via the combined use of the individual compounds.

The present invention thus provides pharmaceutical compositions and methods of treating hepatitis virus infections, especially hepatitis B virus infections, in humans, other mammals, and cells using *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compounds alone or in combination with either an antiviral nucleoside, an antiviral nucleotide, mixtures thereof, and/or an immunomodulating or immunostimulating agent. The *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compounds have basic nitrogen atoms and may be used in the form of a pharmaceutically acceptable salt. Nucleosides and nucleotides useful in the present invention are substituted purine or pyrmidine heterocycles further substituted with R^1 in Formulas II-VI at the 9 position in the case of purines or with R^1 at the 1 position in the case of pyrimidines. The immunomodulating and immunostimulating agents useful in the present invention include those that stimulate immune responses effective in controlling or eliminating viruses or other infectious agents. Non-limiting examples of such immunomodulating and immunostimulating agents include cytokines, peptide agonists, steroids, and classic drugs such as levamisol. The drug combinations of this invention may be provided to a cell or cells, or to a human or other mammalian patient, either in separate pharmaceutically acceptable formulations administered simultaneously or sequentially, formulations containing more than one therapeutic agent, or by an assortment of single agent and multiple agent formulations. However administered, these drug combinations form an anti-hepatitis virus effective amount of components.

As used herein, the term "anti-hepatitis-virus effective amount" refers to an amount of an *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound alone, or a combined amount of (1) an *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound with either an antiviral nucleoside, an antiviral nucleotide, a mixture of an antiviral nucleoside and an antiviral nucleotide, or an immunomodulating/-immunostimulating agent (or mixtures thereof), or (2) a combined amount of an *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound with an antiviral nucleoside, an antiviral nucleotide, or a mixture thereof, and an immunomodulating/-immunostimulating agent (or mixtures thereof) effective in treating hepatitis virus infection. The antiviral effectiveness of the aforementioned combinations may involve a variety of different phenomena associated with viral replication and assembly. These may include, for example, blocking hepatitis viral DNA synthesis; blocking viral transcription; blocking virion assembly; blocking virion release or secretion from infected cells; blocking or altering viral protein function, including the function of viral envelope protein(s); and/or the production of immature or otherwise non-functional virions. The overall effect is an inhibition of viral replication and infection of additional cells, and therefore inhibition of the progress of infection in the patient.

N-substituted-1,5-dideoxy-1,5-imino-D-glucose compounds

N-substituted-1,5-dideoxy-1,5-imino-D-glucitol compounds useful in the present invention are represented by structure I below:



I

wherein R is selected from straight chain alkyl having a chain length of C_7 to C_{20}, more preferably C_8 to C_{20}, more preferably C_8 to C_{16}, more preferably C_8 to C_{12}, even more

preferably C_8 to C_{10}, and most preferably C_9; branched chain alkyl having a chain length of C_3 to C_{20} in the main chain, preferably C_3 to C_{16}, more preferably C_3 to C_{14}, more preferably C_4 to C_{12}, more preferably C_6 to C_{12}, and even more preferably C_8 to C_{10}; alkoxyalkyl; arylalkyl; and cycloalkylalkyl. W, X, Y and Z are independently selected from hydrogen, alkanoyl, aroyl, and trifluoroalkanoyl.

The phrase "in the main chain" refers to the longest contiguous or adjacent chain of carbon atoms starting at the point of attachment of a branched chain alkyl group to the nitrogen atom in the compounds of Formula I.

The terms "alkoxy" and "alkyloxy" embrace linear or branched oxygen-containing radicals each having alkyl portions of one to about ten carbon atoms. Alkoxyalkyl groups ("alkylether" or "oxa" derivatives) useful in the present invention can be C_3 to C_{20}, preferably C_4 to C_{18}, more preferably C_5 to C_{16}, more preferably C_6 to C_{12}, and even more preferably C_8 to C_{12}, wherein one to five non-terminal carbon atoms, preferably one to three non-terminal carbon atoms, more preferably one to two non-terminal carbon atoms, most preferably one non-terminal carbon atom, can be replaced with oxygen.

The term "aryl", alone or in combination with another radical, means a carbocyclic aromatic system containing one, two or three rings wherein such rings may be attached together in a pendent manner or may be fused. The term "aryl" embraces aromatic radicals such as phenyl, naphthyl, tetrahydronaphthyl, indyl, and biphenyl.

The term "arylalkyl" embraces aryl-substituted alkyl radicals such as benzyl, diphenylmethyl, triphenylmethyl, phenylethyl, and diphenylethyl.

The term "cycloalkyl" embraces saturated carbocyclic radicals having three to about twelve carbon atoms. More preferred cycloalkyl radicals are "lower cycloalkyl" radicals having three to about eight carbon atoms. Examples of such radicals include cyclopropyl, cyclobutyl, cyclopentyl and cyclohexyl. "Cycloalkylalkyl" means an alkyl group susbstituted with a cycloalkyl group.

The term "acyl" denotes a radical provided by the residue after removal of hydroxyl from an organic acid. Examples of such acyl radicals include alkanoyl and aroyl radicals. "Alkanoyl" means branched or straight chain alkanecarbonyl having a

chain length of C_1 to C_{20}, preferably C_1 to C_{10}, more preferably C_1 to C_5; "aroyl" means arylcarbonyl; and "trifluoroalkanoyl" means alkanoyl containing three fluoro substituents. Examples of such alkanoyl radicals include formyl, acetyl, propionyl, butyryl, isobutyryl, valeryl, isovaleryl, pivaloyl, hexanoyl, and radicals formed from succinic, glycolic, gluconic, lactic, malic, tartaric, citric, ascorbic, glucuronic, maleic, fumaric, pyruvic, mandelic, pantothenic, β-hydroxybutyric, galactaric and galacturonic acids.

When used in combination with another radical when referring to the imino sugars useful in the present invention, the term "alkyl" means a straight or branched chain hydrocarbon radical containing from 1 to about 20 carbon atoms, preferably 1 to about 16 carbon atoms, more preferably from about 2 to about 12 carbon atoms, more preferably from about 3 to about 10 carbon atoms.

The term "alkenyl" embraces radicals having "cis" and "trans" orientations, or alternatively, "E" and "Z" orientations. The term "alkynyl" embraces linear or branched radicals having at least one carbon-carbon triple bond of two to about twenty carbon atoms or, preferably, two to about twelve carbon atoms. More preferred alkynyl radicals are "lower alkynyl" radicals having two to about six carbon atoms. Examples of alkynyl radicals include propargyl, 1-propynyl, 2-propynyl, 1-butyne, 2-butenyl and 1-pentynyl.

The term "cycloalkylalkyl" embraces alkyl radicals substituted with a cycloalkyl radical. Preferred cycloalkylalkyl radicals are C_4 to C_{20}; more preferred cycloalkylalkyl radicals are C_4 to C_{13}. "lower cycloalkylalkyl" which embrace lower alkyl radicals substituted with a lower cycloalkyl radical as defined above. Examples of such radicals include cyclopropylmethyl, cyclobutylmethyl, cyclopentylmethyl and cyclohexylmethyl.

The present invention comprises any tautomeric forms of compounds of Formula I. The present invention also comprises compounds of Formula I having one or more asymmetric carbons. It is known to those skilled in the art that those imino sugars of the present invention having asymmetric carbon atoms may exist in diastereomeric, racemic, or optically active forms. All of these forms are contemplated within the scope of this invention. More specifically, the present invention includes enantiomers, diastereomers, racemic mixtures, and other mixtures thereof.

Representative *N*-substituted-imino-D-glucitol compounds useful in the present invention include, but are not limited to:

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-methyloctyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-methyloctyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol; and

N-(7,10,13-trioxa-n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol.

Preferred compounds are *N*-(n-nonyl-)-1,5-dideoxy-1,5-imino-D-glucitol and *N*-(n-nonyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate.

The *N*-substituted-imino-D-glucitol compounds, including pro-drugs, useful in the present invention, can be prepared by methods well known in the art. For example, Example 13 of U.S. Patent 5,144,037 discloses a method for the preparation of *N*-nonyl DNJ. At column 4, line 62, U.S. Patent 4,806,650 discloses the preparation of various alkoxy compounds, i.e., with alkyl chains substituted with alkoxy groups. U.S. Patent 4,260,622 discloses the preparation of numerous compounds. Additional documents relevant to the preparation of *N*-substituted-imino-D-glucitol compounds and pro-drugs include U.S. Patents Nos. 4,182,767, 4,260,622, 4,611,058, 4,639,436, and 5,003,072, 5,411,970, and 5,151,519; PCT International Publication WO 95/19172; and Tan et al. (1991) *Journal of Biological Chemistry* 266(22):14504-14510; and the references cited

thereof. Methods for introducing oxygen into alkyl side chains are disclosed in Tan et al., (1994) *Glycobiology* 4(2):141-149, and van den Broek et al. (1994) *Recl. Trav. Chim. Pays-Bas* 113:107-116 discloses the preparation of ether oxygen-containing DNJ compounds.

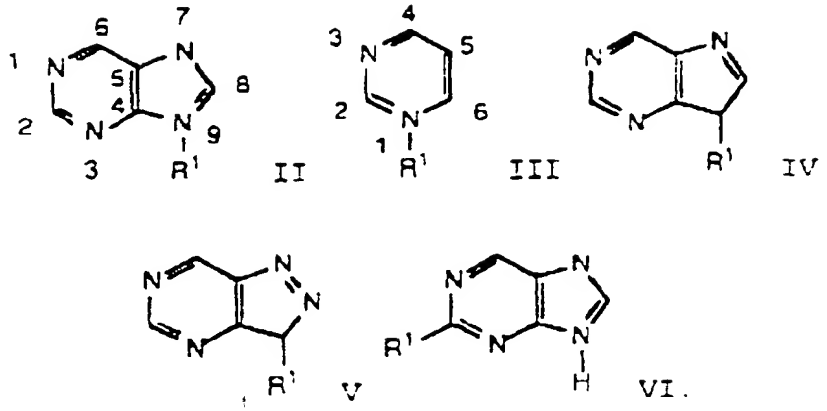
Non-limiting illustrative preparation procedures are presented below in Examples 1 and 2.

In treating hepatitis virus infections, one can use the present *N*-substitututed-1,5-dideoxy-1,5-imino-D-glucitol compounds alone or in combination in the form of salts derived from inorganic or organic acids. These salts include but are not limited to the following: acetate, adipate, alginate, citrate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, camphorate, camphorsulfonate, digluconate, cyclopentanepropionate, dodecylsulfate, ethanesulfonate, glucoheptanoate, glycerophosphate, hemisulfate, heptanoate, hexanoate, fumarate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxy-ethanesulfonate, lactate, maleate, methanesulfonate, nicotinate, 2-naphthalenesulfonate, oxalate, palmoate, pectinate, persulfate, 3-phenylpropionate, picrate, pivalate, propionate, succinate, tartrate, thiocyanate, tosylate, mesylate, and undecanoate.

The basic nitrogen-containing groups can be quaternized with agents such as lower alkyl halides, such as methyl, ethyl, propyl, and butyl chloride, bromides, and iodides; dialkyl sulfates such as dimethyl, diethyl, dibuytl, and diamyl sulfates; long chain halides such as decyl, lauryl, myristyl, and stearyl chlorides, bromides, and iodides; aralkyl halides such as benzyl and phenethyl bromides, and others. Water- or oil-soluble or dispersible products are thereby obtained as desired. The salts are formed by combining the basic compounds with the desired acid.

Nucleosides and Nucleotides

Nucleosides and nucleotides useful in the present invention are purine (II) base compounds or pyrimidine (III) base compounds, or analogs such as compounds IV or V.



II III IV

V VI.

Position numbering for purines and pyrimidines is as shown in structures II and III. R^1 can be selected from hydroxyalkyl, hydroxyalkenyl, carboxyalkyl, carboxyalkenyl, thiolalkyl, alkylthioalkyl, alkoxyalkyl, alkoxyalkenyl, heterocycle, heterocyclo-alkyl, hydroxyalkylalkoxyalkyl, alkoxyalkylalkoxyalkyl, and cycloalkylalkyl. The purine compounds can be further substituted at positions 1, 2, 3, 6, 7, or 8 of the purine heterocycle, and the pyrimidine compounds can be substituted at positions 2, 3, 4, 5, or 6 of the pyrimidine heterocycle. Such substituents can be selected from hydroxy, alkoxy, halo, thiol, amino, carboxyl, mono-substituted amino, di-substituted amino, and alkyl.

The following definitions are applicable only to the structures of Formulas II, III, IV, V and VI of this invention. When used in combination with another radical when referring to the purines and pyrimidines useful in the present invention, the term "alkyl" means a straight or branched chain hydrocarbon radical containing from 1 to 8 carbon atoms, preferably 1 to 4 carbon atoms. When used in combination with another radical, the term "alkenyl" means a straight or branched chain hydrocarbon radical having 1 or more double bonds, containing from 2 to 8 carbon atoms, preferably 1 to 4 carbon atoms. When used alone when referring to purines and pyrimidines useful in the present invention, the term "alkyl" means a straight or branched chain alkyl radical containing from six to 14 carbon atoms, preferably seven to 12 carbon atoms, and most preferably

eight to 11 carbon atoms. The term "aryl" alone or in combination with another radical means a phenyl, naphthyl, or indenyl ring, optionally substituted with one or more substituents selected from alkyl, alkoxy, halogen, hydroxy, or nitro. "Alkanoyl" means branched or straight chain alkanecarbonyl having a chain length of C_1 to C_{20}, preferably C_2 to C_{14}, more preferably C_4 to C_{10}; "aroyl" means arylcarbonyl; and "trifluoroalkanoyl" means alkyl containing three fluoro substituents. "Halogen" means fluorine, chlorine, bromine, or iodine. "Thiol" means sulfur substituted with hydrogen (-SH). "Amino" means nitrogen with two hydrogen atoms; "monosubstituted amino" and "disubstituted amino" mean amino groups further independently substituted with one or more alkyl or arylalkyl groups. "Hydroxyalkyl" means an alkyl group substituted with one or more hydroxyl groups; "hydroxy-alkenyl" means an alkenyl group substituted with one or more hydroxyl groups; "thioalkyl" means an alkyl substituted with one or more thiol (SH) groups; "alkoxyalkyl" means an alkyl substituted with one or more alkyl ether groups; "alkoxyalkenyl" means an alkenyl group substituted with one or more alkyl ether groups; "hydroxyalkylalkoxyalkyl" means an alkoxyalkyl group substituted with a hydroxyalkyl group; "alkoxyalkyl-alkoxyalkyl" means an alkoxyalkyl group substituted with an alkoxyalkyl group; "cycloalkylalkyl" means an alkyl group substituted with a cycloalkyl group. The term "heterocycle," alone or in combination, means a saturated or partially unsaturated 5 or 6-membered ring containing one or more oxygen, nitrogen, and/or sulfur heteroatoms. Said heterocycle can further be substituted with one to four substituents, which can be independently, hydroxy, hydroxyalkyl, thiol, alkoxy, azido, nitro, a halogen atom, amino, mono-substituted amino, or disubstituted amino. Heterocycloalkyl means an alkyl group wherein one or more hydrogen atoms are replaced by a substituted or unsubstituted heterocyclic ring.

Also included are the tautomers of the substituents on the compounds of the invention. Non-limiting examples of tautomers are ketone/enol tautomers, imino/amino tautomers, *N*-substituted imino/*N*-substituted amino tautomers, thiol/thiacarbonyl tautomers, and ring-chain tautomers such as the five and six membered ring oxygen, nitrogen, sulfur, or oxygen- and sulfur- containing heterocycles also containing

substituents alpha to the heteroatoms. Also specifically included in the present invention are enantiomers and diastereomers, as well as racemates and isomeric mixtures of the compounds discussed herein.

Representative nucleoside and nucleotide compounds useful in the present invention include, but are not limited to:

(+)-cis-5-fluoro-1-[2-(hydroxy-methyl)-[1,3-oxathiolan-5-yl]cytosine;

(-)-2'-deoxy-3'-thiocytidine-5'-triphosphate (3TC);

(-)-cis-5-fluoro-1-[2-(hydroxy-methyl)-[1,3-oxathiolan-5-yl]cytosine (FTC);

(-)2',3', dideoxy-3'-thiacytidine [(-)-SddC];

1-(2'-deoxy-2'-fluoro-beta-D-arabinofuranosyl)-5-iodocytosine (FIAC);

1-(2'-deoxy-2'-fluoro-beta-D-arabinofuranosyl)-5-iodocytosine triphosphate (FIACTP);

1-(2'-deoxy-2'-fluoro-beta-D-arabinofuranosyl)-5-methyluracil (FMAU);

1-beta-D-ribofuranosyl-1,2,4-triazole-3-carboxamide;

2',3'-dideoxy-3'-fluoro-5-methyl-dexocytidine (FddMeCyt);

2',3'-dideoxy-3'-chloro-5-methyl-dexocytidine (CldMeCyt);

2',3'-dideoxy-3'-amino-5-methyl-dexocytidine (AddMeCyt);

2',3'-dideoxy-3'-fluoro-5-methyl-cytidine (FddMeCyt);

2',3'-dideoxy-3'-chloro-5-methyl-cytidine (CldMeCyt);

2',3'-dideoxy-3'-amino-5-methyl-cytidine (AddMeCyt);

2',3'-dideoxy-3'-fluorothymidine (FddThd);

2',3'-dideoxy-beta-L-5-fluorocytidine (beta-L-FddC);

2',3'-dideoxy-beta-L-5-thiacytidine;

2',3'-dideoxy-beta-L-5-cytidine (beta-L-ddC);

9-(1,3-dihydroxy-2-propoxymethyl)guanine;

2'-deoxy-3'-thia-5-fluorocytosine;

3'-amino-5-methyl-dexocytidine (AddMeCyt);

2-amino-1,9-[(2-hydroxymethyl-1-(hydroxymethyl)ethoxy]methyl]-6H-purin-6-one (gancyclovir);

2-[2-(2-amino-9H-purin-9y)ethyl]-1,3-propandil diacetate (famciclovir);

2-amino-1,9-dihydro-9-[(2-hydroxy-ethoxy)methyl]6H-purin-6-one (acyclovir);

9-(4-hydroxy-3-hydroxymethyl-but-1-yl)guanine (penciclovir);

9-(4-hydroxy-3-hydroxymethyl-but-1-yl)-6-deoxy-guanine, diacetate (famciclovir);

3'-azido-3'-deoxythymidine (AZT);

3'-chloro-5-methyl-dexocytidine (CldMeCyt);

9-(2-phosphonyl-methoxyethyl)-2',6'-diaminopurine-2',3'-dideoxyriboside;

9-(2-phosphonylmethoxyethyl)adenine (PMEA);

acyclovir triphosphate (ACVTP);

D-carbocyclic-2'-deoxyguanosine (CdG);

dideoxy-cytidine;

dideoxy-cytosine (ddC);

didcoxy-guanine (ddG);

dideoxy-inosine (ddI);

E-5-(2-bromovinyl)-2'-deoxyuridine triphosphate;

fluoro-arabinofuranosyl-iodouracil;

1-(2'-deoxy-2'-fluoro-1-beta-D-arabinofuranosyl)-5-iodo-uracil (FIAU);

stavudine;

9-beta-D-arabinofuranosyl-9H-purine-6-amine monohydrate (Ara-A);

9-beta-D-arabinofuranosyl-9H-purine-6-amine-5'-monophosphate monohydrate (Ara-AMP);

2-deoxy-3'-thia-5-fluorocytidine;

2',3'-dideoxy-guanine; and

2',3'-dideoxy-guanosine.

A preferred compound is (-)-2'-deoxy-3'-thiocytidine-5'-triphosphate (3TC).

Synthetic methods for the preparation of nucleosides and nucleotides useful in the present invention are likewise well known in the art as disclosed in *Acta Biochim. Pol.*, 43, 25-36 (1996); *Swed. Nucleosides Nucleotides* 15, 361-378 (1996), *Synthesis* 12, 1465-1479 (1995), *Carbohyd. Chem.* 27, 242-276 (1995), *Chem. Nucleosides Nucleotides* 3,

421-535 (1994), Ann. Reports in *Med. Chem.*, Academic Press; and *Exp. Opin. Invest. Drugs* 4, 95-115 (1995).

The chemical reactions described in the references cited above are generally disclosed in terms of their broadest application to the preparation of the compounds of this invention. Occasionally, the reactions may not be applicable as described to each compound included within the scope of compounds disclosed herein. The compounds for which this occurs will be readily recognized by those skilled in the art. In all such cases, either the reactions can be successfully performed by conventional modifications known to those skilled in the art, e.g., by appropriate protection of interfering groups, by changing to alternative conventional reagents, by routine modification of reaction conditions, and the like, or other reactions disclosed herein or otherwise conventional will be applicable to the preparation of the corresponding compounds of this invention. In all preparative methods, all starting materials are known or readily preparable from known starting materials.

While nucleoside analogs are generally employed as antiviral agents as is, nucleotides (nucleoside phosphates) must sometimes have to be converted to nucleosides in order to facilitate their transport across cell membranes. An example of a chemically modified nucleotide capable of entering cells is S-1-3-hydroxy-2-phosphonylmethoxypropyl cytosine (HPMPC, Gilead Sciences).

Nucleoside and nucleotide compounds of this invention that are acids can form salts. Examples include salts with alkali metals or alkaline earth metals, such as sodium, potassium, calcium, or magnesium, or with organic bases or basic quaternary ammonium salts.

Immunomodulators and Immunostimulants

A large number of immunomodulators and immuno-stimulants that can be used in the methods of the present invention are currently available. A list of these compounds is provided in Table 1, below.

TABLE 1

AA-2G

adamantylamide dipeptide

adenosine deaminase, Enzon

adjuvant, Alliance

adjuvants, Ribi

adjuvants, Vaxcel

Adjuvax

agelasphin-11

AIDS therapy, Chiron

algal glucan, SRI

algammulin, Anutech

Anginlyc

anticellular factors, Yeda

Anticort

antigastrin-17 immunogen, Ap

antigen delivery system, Vac

antigen formulation, IDBC

antiGnRH immunogen, Aphton

Antiherpin

Arbidol

Aviron

azarole

Bay-q-8939

Bay-r-1005

BCH-1393

Betafectin

Biostim

BL-001

BL-009
Broncostat
Cantastim
CDR1-84-246
cefodizime
chemokine inhibitors, ICOS
CMV peptides, City of Hope
CN-5888
cytokine-releasing agent, St
DHEAS, Paradigm
DISC TA-HSV
J07B
I01A
I01Z
ditiocarb sodium
ECA-10-142
ELS-1
endotoxin, Novartis
FCE-20696
FCE-24089
FCE-24578
FLT-3 ligand, Immunex
FR-900483
FR-900494
FR-901235
FTS-Zn
G-proteins, Cadus
gludapcin
glutaurine

glycophosphopeptical
GM-2
GM-53
GMDP
growth factor vaccine, EntreM
H-BIG, NABI
H-CIG, NABI
HAB-439
Helicobacter pylori vaccine,
herpes-specific immune factor
HIV therapy, United Biomed
HyperGAM+CF
ImmuMax
Immun BCG
immune therapy, Connective
immunomodulator, Evans
immunomodulators, Novacell
imreg-1
imreg-2
Indomune
inosine pranobex
interferon, Dong-A (alpha2)
interferon, Genentech (gamma)
interferon, Novartis (alpha)
interleukin-12, Genetics Ins
interleukin-15, Immunex
interleukin-16, Research Cor
ISCAR-1
J005X

L-644257
licomarasminic acid
LipoTher
LK-409
LK-410
LP-2307
LT(R1926)
LW-50020
MAF, Shionogi
MDP derivatives, Merck
met-enkephalin, TNI
methylfurylbutyrolactones
MIMP
mirimostim
mixed bacterial vaccine, Tem
MM-1
moniliastat
MPLA, Ribi
MS-705
murabutide
murabutide, Vacsyn
muramyl dipeptide derivative
muramyl peptide derivatives
myelopid
N-563
NACOS-6
NH-765
NISV, Proteus
NPT-16416

NT-002
PA-485
PEFA-814
peptides, Scios
peptidoglycan, Pliva
Perthon, Advanced Plant
PGM derivative, Pliva
Pharmaprojects No. 1099
Pharmaprojects No. 1426
Pharmaprojects No. 1549
Pharmaprojects No. 1585
Pharmaprojects No. 1607
Pharmaprojects No. 1710
Pharmaprojects No. 1779
Pharmaprojects No. 2002
Pharmaprojects No. 2060
Pharmaprojects No. 2795
Pharmaprojects No. 3088
Pharmaprojects No. 3111
Pharmaprojects No. 3345
Pharmaprojects No. 3467
Pharmaprojects No. 3668
Pharmaprojects No. 3998
Pharmaprojects No. 3999
Pharmaprojects No. 4089
Pharmaprojects No. 4188
Pharmaprojects No. 4451
Pharmaprojects No. 4500
Pharmaprojects No. 4689

Pharmaprojects No. 4833
Pharmaprojects No. 494
Pharmaprojects No. 5217
Pharmaprojects No. 530
pidotimod
pimelautide
pinafide
PMD-589
podophyllotoxin, Conpharm
POL-509
poly-ICLC
poly-ICLC, Yamasa Shoyu
PolyA-PolyU
Polysaccharide A
protein A, Berlox Bioscience
PS34WO
pseudomonas MAbs, Teijin
Psomaglobin
PTL-78419
Pyrexol
pyriferone
Retrogen
Retropep
RG-003
Rhinostat
rifamaxil
RM-06
Rollin
romurtide

RU-40555
RU-41821
rubella antibodies, ResCo
S-27609
SB-73
SDZ-280-636
SDZ-MRL-953
SK&F-107647
SL04
SL05
SM-4333
Solutein
SRI-62-834
SRL-172
ST-570
ST-789
staphage lysate
Stimulon
suppressin
T-150R1
T-LCEF
tabilautide
temurtide
Theradigm-HBV
Theradigm-HPV
Theradigm-HSV
THF, Pharm & Upjohn
THF, Yeda
thymalfasin

thymic hormone fractions
thymocartin
thymolymphotropin
thymopentin
thymopentin analogues
thymopentin, Peptech
thymosin fraction 5, Alpha
thymostimulin
thymotrinan
TMD-232
TO-115
transfer factor, Viragen
tuftsin, Selavo
ubenimex
Ulsastat
ANGG-
CD-4+
Collag+
COLSF+
COM+
DA-A+
GAST-
GF-TH+
GP-120-
IF+
IF-A+
IF-A-2+
IF-B+
IF-G+

IF-G-1B+
IL-2+
IL-12+
IL-15+
IM+
LHRH-
LIPCOR+
LYM-B+
LYM-NK+
LYM-T+
OPI+
PEP+
PHG-MA+
RNA-SYN-
SY-CW-
TH-A-1+
TH-5+
TNF+
UN

Dosages

The *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compounds useful in the present invention can be administered to humans in an amount in the range of from about 0.1 mg/kg/day to about 100 mg/kg/day, more preferably from about 1 mg/kg/day to about 75 mg/kg/day, and most preferably from about 5 mg/kg/day to about 50 mg/kg/day.

The nucleoside or nucleotide antiviral compound, or mixtures thereof, can be administered to humans in an amount in the range of from about 0.1 mg/person/day to about 500 mg/person/day, preferably from about 10 mg/person/day to about 300

mg/person/day, more preferably from about 25 mg/person/day to about 200 mg/person/day, even more preferably from about 50 mg/person/day to about 150 mg/person/day, and most preferably in the range of from about 1 mg/person/day to about 50 mg/person/day.

Immunomodulators and immunostimulants useful in the present invention can be administered in amounts lower than those conventional in the art. For example, thymosin alpha 1 and thymosin fraction 5 are typically administered to humans for the treatment of HepB infections in an amount of about 900 $\mu g/m^2$, two times per week (*Hepatology* (1988) 8:1270; *Hepatology* (1989) 10:575; *Hepatology* (1991) 14:409; *Gastroenterology* (1995) 108:A1127). In the methods and compositions of the present invention, this dose can be in the range of from about 10 $\mu g/m^2$, two times per week to about 750 $\mu g/m^2$, two times per week, more preferably from about 100 $\mu g/m^2$, two times per week to about 600 $\mu g/m^2$, two times per week, most preferably from about 200 $\mu g/m^2$, two times per week to about 400 $\mu g/m^2$, two times per week. Interferon alfa is typically administered to humans for the treatment of HepC infections in an amount of from about 1 X 10^6 units/person, three times per week to about 10 X 10^6 units/person, three times per week (Simon et al., (1997) *Hepatology* 25:445-448). In the methods and compositions of the present invention, this dose can be in the range of from about 0.1 X 10^6 units/person, three times per week to about 7.5 X 10^6 units/person, three times per week, more preferably from about 0.5 X 10^6 units/person, three times per week to about 5 X 10^6 units/person, three times per week, most preferably from about 1 X 10^6 units/person, three times per week to about 3 X 10^6 units/person, three times per week.

Due to the enhanced hepatitis virus antiviral effectiveness of these immunomodulators and immunostimulants in the presence of the *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compounds useful in the present invention, reduced amounts of other immunomodulators/immunostimulants can be employed in the methods and compositions disclosed herein. Such reduced amounts can be determined by routine monitoring of hepatitis virus in infected patients undergoing therapy. This can be carried out by, for example, monitoring hepatitis viral DNA in patients' serum by slot-blot, dot-

blot, or PCR techniques, or by measurement of hepatitis surface or other antigens, such as the e antigen, in serum. Methods therefor are discussed in Hoofnagle et al., (1997) *New Engl. Jour. Med.* 336(5):347-356, and F.B. Hollinger in *Fields Virology*, Third Ed., Vol. 2 (1996), Bernard N. Fields et al., Eds., Chapter 86, "Hepatitis B Virus," pp. 2738-2807, Lippincott-Raven, Philadelphia, PA, and the references cited therein.

Patients can be similarly monitored during combination therapy employing *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compounds and nucleoside and/or nucleotide antiviral agents to determine the lowest effective doses of each.

The doses described above can be administered to a patient in a single dose or in proportionate multiple subdoses. In the latter case, dosage unit compositions can contain such amounts of submultiples thereof to make up the daily dose. Multiple doses per day can also increase the total daily dose should this be desired by the person prescribing the drug.

Pharmaceutical Compositions

The compounds of the present invention can be formulated as pharmaceutical compositions. Such compositions can be administered orally, parenterally, by inhalation spray, rectally, intradermally, transdermally, or topically in dosage unit formulations containing conventional nontoxic pharmaceutically acceptable carriers, adjuvants, and vehicles as desired. Topical administration may also involve the use of transdermal administration such as transdermal patches or iontophoresis devices. The term parenteral as used herein includes subcutaneous, intravenous, intramuscular, or intrasternal injection, or infusion techniques. Formulation of drugs is discussed in, for example, Hoover, John E., *Remington's Pharmaceutical Sciences*, Mack Publishing Co., Easton, Pennsylvania (1975), and Liberman, H.A. and Lachman, L., Eds., *Pharmaceutical Dosage Forms*, Marcel Decker, New York, N.Y. (1980).

Injectable preparations, for example, sterile injectable aqueous or oleaginous suspensions, can be formulated according to the known art using suitable dispersing or wetting agents and suspending agents. The sterile injectable preparation may also be a

sterile injectable solution or suspension in a nontoxic parenterally acceptable diluent or solvent, for example, as a solution in 1,3-butanediol. Among the acceptable vehicles and solvents that may be employed are water, Ringer's solution, and isotonic sodium chloride solution. In addition, sterile, fixed oils are conventionally employed as a solvent or suspending medium. For this purpose, any bland fixed oil may be employed, including synthetic mono- or diglycerides. In addition, fatty acids such as oleic acid are useful in the preparation of injectables. Dimethyl acetamide, surfactants including ionic and non-ionic detergents, and polyethylene glycols can be used. Mixtures of solvents and wetting agents such as those discussed above are also useful.

Suppositories for rectal administration of the compounds discussed herein can be prepared by mixing the active agent with a suitable non-irritating excipient such as cocoa butter, synthetic mono-, di-, or triglycerides, fatty acids, or polyethylene glycols which are solid at ordinary temperatures but liquid at the rectal temperature, and which will therefore melt in the rectum and release the drug.

Solid dosage forms for oral administration may include capsules, tablets, pills, powders, and granules. In such solid dosage forms, the compounds of this invention are ordinarily combined with one or more adjuvants appropriate to the indicated route of administration. If administered *per os*, the compounds can be admixed with lactose, sucrose, starch powder, cellulose esters of alkanoic acids, cellulose alkyl esters, talc, stearic acid, magnesium stearate, magnesium oxide, sodium and calcium salts of phosphoric and sulfuric acids, gelatin, acacia gum, sodium alginate, polyvinylpyrrolidone, and/or polyvinyl alcohol, and then tableted or encapsulated for convenient administration. Such capsules or tablets can contain a controlled-release formulation as can be provided in a dispersion of active compound in hydroxypropylmethyl cellulose. In the case of capsules, tablets, and pills, the dosage forms can also comprise buffering agents such as sodium citrate, or magnesium or calcium carbonate or bicarbonate. Tablets and pills can additionally be prepared with enteric coatings.

For therapeutic purposes, formulations for parenteral administration can be in the form of aqueous or non-aqueous isotonic sterile injection solutions or suspensions. These

solutions and suspensions can be prepared from sterile powders or granules having one or more of the carriers or diluents mentioned for use in the formulations for oral administration. The compounds can be dissolved in water, polyethylene glycol, propylene glycol, ethanol, corn oil, cottonseed oil, peanut oil, sesame oil, benzyl alcohol, sodium chloride, and/or various buffers. Other adjuvants and modes of administration are well and widely known in the pharmaceutical art.

Liquid dosage forms for oral administration can include pharmaceutically acceptable emulsions, solutions, suspensions, syrups, and elixirs containing inert diluents commonly used in the art, such as water. Such compositions can also comprise adjuvants, such as wetting agents, emulsifying and suspending agents, and sweetening, flavoring, and perfuming agents.

The amount of active ingredient that can be combined with the carrier materials to produce a single dosage form will vary depending upon the patient and the particular mode of administration.

Certain of the pharmaceutical compounds of this invention which are administered in accordance with the methods of the invention can serve as prodrugs to other compounds of this invention. Prodrugs are drugs that can be chemically converted *in vivo* or *in vitro* by biological systems into an active derivative or derivatives. Prodrugs are administered in essentially the same fashion as the other pharmaceutical compounds of the invention. Non-limiting examples are the esters of the *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compounds of this invention.

Compounds of the combinations of this invention, for example *N*-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol and various nucleosides or nucleotides, may be acids or bases. As such, they may be used to form salts with one another. Nucleosides are purine or pyrimidine compounds lacking a phosphate ester. Compounds of Formulas II, III, IV, V, or VI herein without a phosphate ester but containing a carboxylic acid moiety could form a salt with an *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of the present invention. Nucleotides are purine or pyrimidine compounds that are mono-, di-, or triphosphate esters. These phosphate esters contain free -OH groups that are acidic,

and that can form salts with inorganic bases or organic bases. Salt formation with organic bases depends on the pKa of the acid and base. The *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compounds disclosed herein are basic, and form pharmaceutically acceptable salts. In the present case, useful salts can be formed not only with pharmaceutically acceptable acids, but also with biologically active acids such as the nucelosides and nucleotides disclosed herein. These salts can be prepared in the conventional manner for preparing salts, as is well known in the art. For example, one can treat the free base of an *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound with a nucleotide analog of Formula II, III, IV, V, or VI to form a salt. This can be performed as a separate chemical reaction, or as part of the formulation process. The limiting reagent in the salt forming reaction is either the acid or base, as selected by the artisan to obtain a suitable biological result. The formulation can contain mixtures of different salts, acids, or free bases as desired. For example, the phosphoric acid form of (-)-2'-deoxy-3'-thiocytidine-5'-triphosphate will form a salt with the base form of *N*-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol or *N*-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate. This type of salt can then be provided to the patient in a pharmaceutically acceptable formulation, as a pure single salt, or as part of a mixture.

In some cases, the salts can also be used as an aid in the isolation, purification, or resolution of the compounds of this invention.

Treatment Regimen

The regimen for treating a patient suffering from a hepatitis virus infection with the compounds and/or compositions of the present invention is selected in accordance with a variety of factors, including the age, weight, sex, diet, and medical condition of the patient, the severity of the infection, the route of administration, pharmacological considerations such as the activity, efficacy, pharmacokinetic, and toxicology profiles of the particular compounds employed, and whether a drug delivery system is utilized.

Administration of the drug combinations disclosed herein should generally be continued over a period of several weeks to several months or years until virus titers

reach acceptable levels, indicating that infection has been controlled or eradicated. As noted above, patients undergoing treatment with the drug combinations disclosed herein can be routinely monitored by measuring hepatitis viral DNA in patients' serum by slot-blot, dot-blot, or PCR techniques, or by measurement of hepatitis antigens, such as hepatitis B surface antigen (HBsAg) and hepatitis B e antigen (HBeAg), in serum to determine the effectiveness of therapy. In chronic hepatitis B, for example, remissions are characterized by the disappearance of hepatitis B viral DNA, i.e., reduction to undetectable levels as measured by hybridization tests capable of detecting levels $\geq 10^5$ genomes per ml of serum, and HBeAg from serum despite the continued presence of HBsAg. These serologic events are followed by improvement in the biochemical and histologic features of the disease. The end point of successful treatment in most trials of antiviral therapy is the disappearance of HBeAg and viral DNA from serum. In patients in whom the e antigen disappears, remission is usually sustained, and results in an inactive HBsAg carrier state. Many patients eventually become HBsAg-negative (see Hoofnagle et al., (1997) *New Engl. Jour. Med.* 336(5):347-356 for a review).

Continuous analysis of the data obtained by these methods permits modification of the treatment regimen during therapy so that optimal amounts of each component in the combination are administered, and so that the duration of treatment can be determined as well. Thus, the treatment regimen/dosing schedule can be rationally modified over the course of therapy so that the lowest amounts of each of the antiviral compounds used in combination which together exhibit satisfactory anti-hepatitis virus effectiveness are administered, and so that administration of such antiviral compounds in combination is continued only so long as is necessary to successfully treat the infection.

The following non-limiting examples serve to illustrate various aspects of the present invention.

Example 1

Preparation of

1,5-(butylimino)-1,5-dideoxy-D-glucitol

A solution of 1,5-dideoxy-1,5-imino-D-glucitol (5.14 g, 0.0315 mole), butyraldehyde (3.35 ml, 0.0380 mole) and Pd black (1 g) in 200 ml methanol was hydrogenated (60 psi/29°C/21 hrs.). After filtering the resulting mixture, the filtrate was concentrated *in vacuo* to an oil. The title compound was crystallized from acetone, and recrystallized from methanol/acetone, m.p. ca. 132°C. The structure assignment was supported by NMR, infrared spectra and elemental analysis.

Analysis calcd. for $C_{10}H_{21}NO_4$: C, 54.78; H, 9.65; N, 6.39. Found: C, 54.46; H, 9.33; N, 6.46.

Example 2

Preparation of

1,5-(butylimino)-1,5-dideoxy-D-glucitol, tetraacetate

Acetic anhydride (1.08 g, 0.0106 mole) was added to the title compound of Example 1 (0.50 g, 0.0023 mole) in 5 ml pyridine and stirred for 17 days at room temperature. The product was evaporated under nitrogen gas. The resulting title compound was purified by silica gel chromatography. Structure assignment was supported by NMR, infrared spectra and elemental analysis.

Analysis calcd. for $C_{18}H_{29}NO_8$: C, 55.80; H, 7.54; N, 3.62. Found: C, 55.42; H, 7.50; N, 3.72.

Example 3

Anti-Hepatitis B Virus Activity of Various

***N*-Substituted-1,5-Dideoxy-1,5-Imino-D-Glucitol Compounds**

In Vitro

The anti-hepatitis B virus activity and effect on cell viability of a number of different *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compounds were assessed using

an *in vitro* assay employing chronically hepatitis B virus secreting HepG2.2.15 cells. The method employed was essentially that described in Block et al. (1994) *Proc. Natl. Acad. Sci.* USA 91:2235-2239. The results are shown in Tables 2 and 3.

TABLE 2

Effect of *N*-Substituted-1,5-Dideoxy-1,5-Imino-D-Glucitol Compounds on Hepatitis B Virus Secretion and Viability of HepG2.2.15 Cells

Compound and [Concentration][1]		% Viable +/-1 S.D.[2]	Relative amount of HBV secreted, as a % of control[3]
Control		90 +/-7 (n = 4)	100
NBDNJ[4]	[200]	94 +/-6 (n = 10)	37.0 +/-13 (n = 15)
NBDNJ[4]	[1000]	88 +/-8 (n = 10)	3.2 +/-5 (n = 15)
1	[200]	90 +/-2 (n = 4)	85.0 +/-5 (n = 8)
1	[1000]	87 +/-3 (n = 4)	35.0 +/-6 (n = 8)
2	[200]	90 +/-6 (n = 4)	107.0 +/-12(n = 3)
2	[1000]	89 +/-4 (n = 4)	38.0 +/-15 (n = 3)
3	[200]	n.d.[5]	45.0 +/-30 (n = 3)
3	[1000]	n.d.[5]	5.0 +/-20 (n = 3)

[1]Chronically HBV secreting 2.2.15 cells (approximately 500,000 per well) were incubated in the presence of indicated compound for three days.

[2]After 3 days of culture in the absence or presence of compound, cells were removed by trypsin treatment, incubated with trypan blue, and visually examined for dye exclusion by microscopy. Values are the percentage, relative to the total number of cells examined, of cells excluding trypan blue (trypan blue exclusion was considered equivalent to viability).

[3]After 3 days of incubation in the absence or presence of compound, secreted virions were immunoprecipitated from the culture medium with monoclonal antibody specific for preS1 antigen (Meisel et al. (1995) *Intervirology* 37:330-339; Lu et al. (1995) *Virology* 213:660-665). Viral DNA present in the immunoprecipitates was detected by densitrometric quantification of the DNA fragment of the correct size resulting from a polymerase chain reaction. The amount of DNA amplified from control (cells receiving no compound) is assumed to be 100%.

[4]NBDNJ: *N*-(n-butyl-)-1,5-dideoxy-1,5-imino-D-glucitol; N-butyl DNJ.

[5]Although trypan blue viability staining was not performed, cells appeared unremarkable (healthy) by gross microscopic examination.

S.D.: standard deviation.

Compounds:

1: *N*-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol

2: *N*-(n-butyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate

3: *N*-(2-ethylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol

TABLE 3

Effect of *N*-Substituted-1,5-Dideoxy-1,5-Imino-D-Glucitol Compounds on Hepatitis B Virus Secretion and Viability of HepG2.2.15 Cells

Compound	Concentration Resulting In 90% HBV Secretion Inhibition[1]	Concentration Resulting In 50% Reduction in MTT[2]
1	0.5 - 1.0*	100-200
2	>200**	n.d.[3]

[1]in μgs per ml. and based upon duplicate PCR results.

[2]in μgs per ml.; MTT: 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide.

The MTT-based colorimetric assay is a measurement of cell viability (Heo et al. (1990) *Cancer Research* 50:3681-3690).

[3]Not determined.

*lowest concentration tested.

**there was no inhibition seen at the highest concentration used (200 μgs/ml).

Compounds:

1: *N*-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol

2: *N*-(n-butyl)-1,5-dideoxy-1,5-imino-D-glucitol, 3,4-diacetate

Example 4

Anti-Hepatitis B Virus Activity of (-)-2'-deoxy-3'-thiocytidine-5'-triphosphate (3TC) Alone and in Combination with *N*-nonyl-DNJ

The anti-hepatitis B virus effect of (-)-2'-deoxy-3'-thiocytidine-5'-triphosphate (3TC) alone and in combination with *N*-nonyl-DNJ was determined according to Korba ((1996) *Antiviral Research* 29(1):49-51), using the "combostat" strategy (Comstat Program, Combostat Corp., Duluth, MN). The combostat method involves serially diluting the IC-90 of each compound. The IC-90 of *N*-nonyl-DNJ has been determined to be between 4 and 10 μg/ml (T. Block and G. Jacob, unpublished observation). The accepted IC-90 for 3TC in HepG 2.2.15 (2.2.15) cells is 300nM to 500nM (Doong et al. (1991) *Proc. Natl. Acad. Sci. USA* 88:8495-8499).

2.2.15 cells, described in Sells et al. (1987) *Proc. Natl. Acad. Sci. USA* 84:1005-1009, were maintained in RPMI 1640 medium (Gibco BRL, #31800-022) supplemented with 10% fetal bovine serum, 200 μg/ml G418 (Gibco BRL 066-1811). Cells were seeded into 25 cm^2 flasks at 80% confluency. Five days later, flasks in triplicate received either no compound, serial dilutions of 3TC alone, or serial dilutions of 3TC plus *N*-nonyl-DNJ. At 2, 4, and 6 days after addition of compound (with medium replacement on those days), the amount of hepatitis B virus (HBV) DNA in the culture medium was determined by PCR analysis of polyethyleneglycol-sedimented particles.

Thus, in these experiments, enveloped particles were not distinguished from nucleocapsids. PCR-amplified products were resolved by agarose gel electrophoresis (1.5% agarose), and the 538 nucleotide fragment was quantified by band scanning (HP Jet Imager). The amount of HBV recovered from untreated cells is assumed to be 100%. Data from the 6-day time point are presented in Figure 1 as the average values from at least three separate flasks, and the standard error was never greater than 20%, with an average error of 12%.

For each of the three time point series tested, the combination of 3TC plus *N*-nonyl-DNJ was significantly more effective in inhibiting HBV secretion than either compound alone. Conclusions based upon PCR analysis alone make it difficult to assign precise IC-50 values. The extreme sensitivity and delicate nature of PCR, for example, may account for the inability to achieve greater than 90% inhibition of HBV by 3TC alone, even at 300nM. Every experiment included controls to assure that PCR was performed in a range of concentrations of DNA in which the reaction yields results proportional to the amount of DNA in the sample. Resolution is approximately 3-fold, i.e., 3-fold differences in DNA concentrations can be detected. The inability to consistently detect less than 3-fold differences probably explains the failure of 3TC alone to achieve 90% inhibition. This suggests that a very high standard of inhibition must be met for the PCR to detect inhibition. Consequently, the trend, over three separate time points, is clear: the combined effect of 3TC plus *N*-nonyl-DNJ is greater than that of either compound alone, or the additive individual effects of each compound. These data suggest that the IC-50 of 3TC has been moved from about 60 nM to about 0.48 nM when 0.016 μg/ml *N*-nonyl-DNJ is present.

Example 5

Anti-Hepatitis B Virus Effect of *N*-nonyl-DNJ Alone in a Woodchuck Model

In order to evaluate the efficacy of *N*-nonyl-DNJ in combination with 3TC (or other nucleoside or nucleotide analogs) against Hepatitis B virus in a woodchuck animal

model, an monotherapy experiment using *N*-nonyl-DNJ alone was first conducted. This was necessary to determine if *N*-nonyl-DNJ has any anti-HBV effect in the woodchuck and, if *N*-nonyl-DNJ has a beneficial effect, to design a combination study based on the dose-response relationship of this drug alone.

Therefore, five groups of four animals each (all groups had both sexes, all but the control had two of each sex) were assigned to 0, 12.5, 25, 50, and 100 mg/kg/day with BID oral dosing. These were lab-reared wild animals. All animals were infected with woodchuck hepatitis virus (WHV) as neonates, and had been tested positive on serological tests for WHV surface antigen. Blood samples were drawn one week prior to dosing (-1 week), immediately before dosing (0 weeks), weekly during dosing (1, 2, 3, and 4 weeks), and after the end of dosing (5, 6, 8, and 10 weeks).

There are two measures of drug efficacy: reduction in total HBV DNA (measured by quantitative PCR), and reduction in HBV DNA from capsids with intact surface glycoproteins, which is the active form of the virus (measured by an ELISA-like immune precipitation assay followed by quantitative PCR). Cell culture experiments with *N*-nonyl-DNJ demonstrated little or no effect of this compound on total HBV DNA, but a marked effect on the immune precipitated DNA (IPDNA). Not surprisingly, the IPDNA assay is quite variable; as a partial compensation for this, four assay runs were conducted, each containing samples from all animals, but different subsets of the study weeks.

To summarize the results, *N*-nonyl-DNJ had no effect on total HBV DNA measurements, which were essentially constant for all dose levels over the pre-dose and dosed portions of the study. On the other hand, IPDNA levels were not constant over the study period. The low dose animals tended to have increasing levels of IPDNA over the dosing period (weeks 0-4), while high dose animals tended to have decreasing levels of IPDNA over the same period. Fitting a straight line to each animal's weekly responses gave a significant difference in the slope of these lines due to either dose or plasma level of drug. The plasma levels of drug were also quite variable: animals with the lowest plasma levels in their dose group had lower plasma levels than the animals with the

highest plasma levels from the next lower dose group. There were no differences between responses of males and females on any of the measures.

Plasma Levels

There were no clear patterns in the changes in plasma levels of *N*-nonyl-DNJ which could be related to week of dosing or time since previous dose. Because the plasma levels within an animal seemed reasonably consistent during dosing, the median plasma level for each animal was used for subsequent modeling. The plasma levels for each week of the dosing period are plotted for each animal vs. dose (a small amount of random noise is added to the dose level so points which would lie on top of each other on the plot can be distinguished) (Figure 2).

HBV DNA

The total HBV DNA levels were essentially constant over time within each animal (data not shown). There was a faint hint of a dose-response relationship with decreasing levels of virus with increasing levels of drug, except that three animals at the highest dose had very high virus levels. It is not possible to conclude that there is any relationship between dose of *N*-nonyl-DNJ and total HBV DNA. It is possible that there are two populations of animals, responders (such as animal r) and non-responders (animals i, m, and d), but more data would be required to permit a firm conclusion on this point.

Immune Precipitated HBV DNA

Substantial variation existed in the IPDNA assay, both between assay runs and within assay runs (data not shown). Even so, it was possible to observe and model a slope over weeks 0-4 which is generally increasing for low dose animals and decreasing for high dose animals. This change in slope was statistically significant ($p < 0.005$).

Before models are fitted to the data, a log transform was applied because: 1) the variation in IPDNA increases with increasing IPDNA values; the log transformation gives

values with a nearly constant variation, and 2) it is expected that drug effects will appear as a constant multiplier of the lPDNA level. Because there are zero values of lPDNA, a small value (about 1/2 of the smallest non-zero value) was added to all values before the log transform.

Two approaches were used to model the changes in slope to week with dose of *N*-nonyl-DNJ: a linear modeling approach and a nonlinear model. Both approaches assume that the (linear) rate of change of the Log(IPDNA) measure over the dosing period is the "right" measure to reflect the effect of the drug on the virus. Both approaches are fit in stages, and the first stage is common to both approaches. First, a simple straight line regression model is fit using weeks 0-4 to predict log(IPDNA + 10) separately for each animal by run combination. In the second stage, the response variable is the slope fitted in the first stage.

For the linear approach, a model is fit with slope to week as the response where run is considered a block, dose has a significant effect (almost all of this effect is due to a slope to dose), and the relevant error for testing the effect of dose is the variation among animals treated alike (after the adjustment for the runs as blocks). This is similar to using the calibration data within each run to first adjust each run's data to a common virus DNA concentration; the difference is that here the data from the woodchucks are used for the run adjustment rather than only the calibration data.

For the nonlinear approach, a four parameter logistic model is fit with the slope to week as the response and the dose as the predictor. Again, run is considered a block, but because no run has all weeks, it is not possible to fully reflect the blocking in the nonlinear approach. Even so, the nonlinear model yields an EC50 of 7.88 mg/kg/BID dose. The average maximum slope observed was 2.71 additional Log(IPDNA μg/mL)/week, or an increase of about 150%/week, the average minimum slope observed with *N*-nonyl-DNJ is 0.31 fewer Log(IPDNA μg/mL)/week), or about a decrease of about 25%/week. The slopes, the fitted model, the parameter estimates from the model, and the approximate standard errors for these parameters are all shown in Figure 3. The data indicate an approximate effective monotherapy dose of *N*-nonyl-DNJ in woodchucks of

about 16 mg/kg/day. Whether in woodchucks or humans, the effective dose of both the *N*-alkyl-DNJ and nucleoside or nucleotide antiviral agent administered in combination therewith can be administered in two equal daily subdoses (i.e., B.I.D.).

Figures 2 and 3 show letters to indicate animals. Table 4 shows two of the animal codes, the sex, and the dose.

TABLE 4

Animal Codes, Sex, and Dose

Animal Number	Letter Code	Sex	Dose
F95343	b	F	0
M96364	n	M	0
F96304	k	F	0
F96301	j	F	0
M96285	h	M	6.25
F96283	g	F	6.25
F96391	o	F	6.25
M96305	l	M	6.25
F96271	f	F	12.5
M96256	e	M	12.5
M96404	s	M	12.5
F96392	p	F	12.5
F96163	c	F	25
M96414	t	M	25
F96393	q	F	25
M95322	a	M	25
M96286	i	M	50
F96231	d	F	50
F96402	r	F	50
M96363	m	M	50

Example 6

Antiviral Study to Test the Activity of *N*-nonyl-DNJ in Combination with 3TC in a Woodchuck Model of Hepatitis B Virus Infection

The combined activity of *N*-nonyl-DNJ and the nucleoside analog 3TC can be assessed using the woodchuck model of hepatitis B virus infection. Twenty-eight woodchucks with persistent woodchuck hepatitis virus (WHV) infection can be utilized. Groups of woodchucks can be treated orally with 3TC alone (s.i.d.), with *N*-nonyl-DNJ alone (b.i.d.), or with combinations of the two drugs. The antiviral activity of the individual drugs and combinations can be assessed by measuring serum WHV DNA during treatment, and comparing the results of treated groups to placebo treated controls.

Twenty-eight woodchucks with established persistent WHV infection can be used, all of which were experimentally infected with WHV during the first week of life. All can be WHsAg positive at the time the study is initiated.

A total of eight experimental groups can be used. Woodchucks in each group can be stratified on the basis of gender, body weight, and age. 3TC can be administered orally as an aqueous suspension of Epivir (Glaxo-Wellcome) tablets one time per day. *N*-nonyl-DNJ can also be administered orally in aqueous solution, in two divided doses. Treatment with both drugs can be followed by the administration of 4 to 5 mls of semisynthetic liquid woodchuck diet to insure complete ingestion of the drugs.

The experimental groups can be as follows:

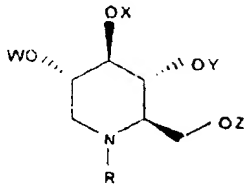
Group ID	No.	3TC (mg/kg/day)	*N*-nonyl-DNJ (mg/kg/day)
1	4	0.0	0.0
2	3	3.0	0.0
3	3	9.0	0.0
4	3	0.0	4.0
5	3	0.0	12.0
6	4	1.5	2.0
7	4	4.5	6.0
8	4	9.0	12.0

Woodchucks can be anesthetized (50mg/kg ketamine, 5mg/kg zylazine), weighed, and blood samples obtained prior to initial treatment, at weekly intervals during the six week period of treatment, and at 1, 2, and 4 weeks following treatment. Serum can be harvested and divided into aliquots. One aliquot can be used for analysis of WHV DNA by dot blot hybridization and for WHsAg by ELISA. CBCs and clinical biochemical profiles can be obtained prior to treatment and at the end of treatment. A second aliquot can be maintained as an archive sample. Other aliquots of serum can be used for drug analysis and special WHV DNA analyses.

The invention being thus described, it will be obvious that the same can be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the present invention, and all such modifications and equivalents as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

What Is Claimed Is:

1. A method for treating a hepatitis virus infection in a mammal, comprising administering to said mammal an anti-hepatitis virus effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof:



(I)

wherein R is selected from the group consisting of straight chain alkyl having a chain length of C_7 to C_{20}, branched chain alkyl having a chain length of C_3 to C_{20} in the main chain, alkoxyalkyl, arylalkyl, and cycloalkylalkyl, and

wherein W, X, Y and Z are each independently selected from the group consisting of hydrogen, alkanoyl, aroyl, and trifluoroalkanoyl.

2. The method of claim 1, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each hydrogen.

3. The method of claim 2, wherein R is nonyl.

4. The method of claim 1, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each alkanoyl.

5. The method of claim 4, wherein R is nonyl.

6. The method of claim 5, wherein said alkanoyl is butanoyl.

7. The method of claim 1, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of:

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-methyloctyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

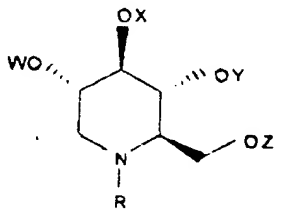
N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-methyloctyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;
N-(3-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(9-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(7-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;
N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol; and
N-(7,10,13-trioxa-n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol.

8. The method of claim 1, wherein said pharmaceutically acceptable salt is selected from the group consisting of acetate, adipate, alginate, citrate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, camphorate, camphorsulfonate, digluconate, cyclopentanepropionate, dodecylsulfate, ethanesulfonate, glucoheptanoate, glycerophosphate, hemisulfate, heptanoate, hexanoate, fumarate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxy-ethanesulfonate, lactate, maleate, methanesulfonate, nicotinate, 2-naphthalenesulfonate, oxalate, palmoate, pectinate,

persulfate, 3-phenylpropionate, picrate, pivalate, propionate, succinate, tartrate, thiocyanate, tosylate, mesylate, and undecanoate.

9. A method for treating a hepatitis virus infection in a mammal, comprising administering to said mammal an antiviral composition comprising an antiviral effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof:



(I)

wherein R is selected from the group consisting of straight chain alkyl having a chain length of C_7 to C_{20}, branched chain alkyl having a chain length of C_3 to C_{20} in the main chain, alkoxyalkyl, arylalkyl, and cycloalkylalkyl, and

wherein W, X, Y and Z are each independently selected from the group consisting of hydrogen, alkanoyl, aroyl, and trifluoroalkanoyl.

10. The method of claim 9, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each hydrogen.

11. The method of claim 10, wherein R is nonyl.

12. The method of claim 9, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each alkanoyl.

13. The method of claim 12, wherein R is nonyl.

14. The method of claim 13, wherein said alkanoyl is butanoyl.

15. The method of claim 9, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of:

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-methyloctyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-methyloctyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

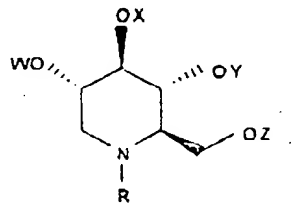
N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol; and

N-(7,10,13-trioxa-n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol.

16. The method of claim 9, wherein said pharmaceutically acceptable salt is selected from the group consisting of acetate, adipate, alginate, citrate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, camphorate, camphorsulfonate, digluconate, cyclopentanepropionate, dodecylsulfate, ethanesulfonate, glucoheptanoate, glycerophosphate, hemisulfate, heptanoate, hexanoate, fumarate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxy-ethanesulfonate, lactate, maleate, methanesulfonate, nicotinate, 2-naphthalenesulfonate, oxalate, palmoate, pectinate,

persulfate, 3-phenylpropionate, picrate, pivalate, propionate, succinate, tartrate, thiocyanate, tosylate, mesylate, and undecanoate.

17. A method for treating a hepatitis virus infection in a mammal, comprising administering to said mammal an antiviral composition consisting essentially of an antiviral effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof:



(I)

wherein R is selected from the group consisting of straight chain alkyl having a chain length of C_7 to C_{20}, branched chain alkyl having a chain length of C_3 to C_{20} in the main chain, alkoxyalkyl, arylalkyl, and cycloalkylalkyl, and

wherein W, X, Y and Z are each independently selected from the group consisting of hydrogen, alkanoyl, aroyl, and trifluoroalkanoyl.

18. The method of claim 17, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each hydrogen.

19. The method of claim 18, wherein R is nonyl.

20. The method of claim 17, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each alkanoyl.

21. The method of claim 20, wherein R is nonyl.

22. The method of claim 21, wherein said alkanoyl is butanoyl.

23. The method of claim 17, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of:

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-methyloctyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-pentylpentylhexyl)-1,5-dideoxy 1,5-imino-D-glucitol, tetrabutyrate;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-methyloctyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

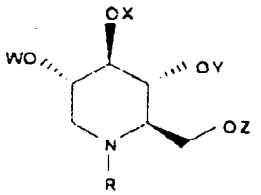
N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol; and

N-(7,10,13-trioxa-n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol.

24. The method of claim 17, wherein said pharmaceutically acceptable salt is selected from the group consisting of acetate, adipate, alginate, citrate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, camphorate, camphorsulfonate, digluconate, cyclopentanepropionate, dodecylsulfate, ethanesulfonate, glucoheptanoate, glycerophosphate, hemisulfate, heptanoate, hexanoate, fumarate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxy-ethanesulfonate, lactate, maleate, methanesulfonate, nicotinate, 2-naphthalenesulfonate, oxalate, palmoate, pectinate,

persulfate, 3-phenylpropionate, picrate, pivalate, propionate, succinate, tartrate, thiocyanate, tosylate, mesylate, and undecanoate.

25. A method for treating a hepatitis virus infection in a mammal, consisting essentially of administering to said mammal an antiviral effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof:



(I)

wherein R is selected from the group consisting of straight chain alkyl having a chain length of C_7 to C_{20}, branched chain alkyl having a chain length of C_3 to C_{20} in the main chain, alkoxyalkyl, arylalkyl, and cycloalkylalkyl, and

wherein W, X, Y and Z are each independently selected from the group consisting of hydrogen, alkanoyl, aroyl, and trifluoroalkanoyl.

26. The method of claim 25, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each hydrogen.

27. The method of claim 26, wherein R is nonyl.

28. The method of claim 25, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each alkanoyl.

29. The method of claim 28, wherein R is nonyl.

30. The method of claim 29, wherein said alkanoyl is butanoyl.

31. The method of claim 25, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of:

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-methyloctyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-methyloctyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

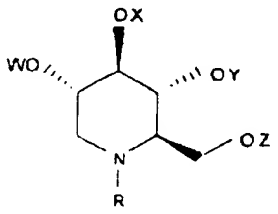
N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol; and

N-(7,10,13-trioxa-n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol.

32. The method of claim 25, wherein said pharmaceutically acceptable salt is selected from the group consisting of acetate, adipate, alginate, citrate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, camphorate, camphorsulfonate, digluconate, cyclopentanepropionate, dodecylsulfate, ethanesulfonate, glucoheptanoate, glycerophosphate, hemisulfate, heptanoate, hexanoate, fumarate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxy-ethanesulfonate, lactate, maleate, methanesulfonate, nicotinate, 2-naphthalenesulfonate, oxalate, palmoate, pectinate, persulfate, 3-phenylpropionate, picrate, pivalate, propionate, succinate, tartrate, thiocyanate, tosylate, mesylate, and undecanoate.

33. A method for treating a hepatitis virus infection in a mammal, consisting essentially of administering to said mammal an antiviral effective amount of an antiviral compound consisting essentially of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof:



(I)

wherein R is selected from the group consisting of straight chain alkyl having a chain length of C_7 to C_{20}, branched chain alkyl having a chain length of C_3 to C_{20} in the main chain, alkoxyalkyl, arylalkyl, and cycloalkylalkyl, and

wherein W, X, Y and Z are each independently selected from the group consisting of hydrogen, alkanoyl, aroyl, and trifluoroalkanoyl.

34. The method of claim 33, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each hydrogen.

35. The method of claim 34, wherein R is nonyl.

36. The method of claim 33, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each alkanoyl.

37. The method of claim 36, wherein R is nonyl.

38. The method of claim 37, wherein said alkanoyl is butanoyl.

39. The method of claim 33, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of:

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-methyloctyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-methyloctyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

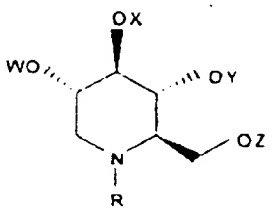
N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;
N-(3-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(9-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(7-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;
N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol; and
N-(7,10,13-trioxa-n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol.

40. The method of claim 33, wherein said pharmaceutically acceptable salt is selected from the group consisting of acetate, adipate, alginate, citrate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, camphorate, camphorsulfonate, digluconate, cyclopentanepropionate, dodecylsulfate, ethanesulfonate, glucoheptanoate, glycerophosphate, hemisulfate, heptanoate, hexanoate, fumarate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxy-ethanesulfonate, lactate, maleate, methanesulfonate, nicotinate, 2-naphthalenesulfonate, oxalate, palmoate, pectinate, persulfate, 3-phenylpropionate, picrate, pivalate, propionate, succinate, tartrate, thiocyanate, tosylate, mesylate, and undecanoate.

41. A method for treating a hepatitis virus infection in a mammal, consisting essentially of administering to said mammal a first amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof:



(I)

wherein R is selected from the group consisting of straight chain alkyl having a chain length of C_7 to C_{20}, branched chain alkyl having a chain length of C_3 to C_{20} in the main chain, alkoxyalkyl, arylalkyl, and cycloalkylalkyl, and

wherein W, X, Y and Z are each independently selected from the group consisting of hydrogen, alkanoyl, aroyl, and trifluoroalkanoyl; and

a second amount of an antiviral compound selected from the group consisting of a nucleoside antiviral compound, a nucleotide antiviral compound, an immunomod-ulator, an immunostimulant, and mixtures thereof,

wherein said first and second amounts of said compounds together comprise an anti-hepatitis virus effective amount of said compounds.

42. The method of claim 41, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each hydrogen.

42. The method of claim 42, wherein R is nonyl.

43. The method of claim 41, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each alkanoyl.

44. The method of claim 43, wherein R is nonyl.

45. The method of claim 44, wherein said alkanoyl is butanoyl.

46. The method of claim 41, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of:

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-methyloctyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-methyloctyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol; and

N-(7,10,13-trioxa-n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol.

47. The method of claim 41, wherein said nucleoside or nucleotide antiviral compound is selected from the group consisting of:

(+)-cis-5-fluoro-1-[2-(hydroxy-methyl)-[1,3-oxathiolan-5-yl]cytosine;

(-)-2'-deoxy-3'-thiocytidine-5'-triphosphate (3TC);

(-)-cis-5-fluoro-1-[2-(hydroxy-methyl)-[1,3-oxathiolan-5-yl]cytosine (FTC);

(-)2',3', dideoxy-3'-thiacytidine [(-)-SddC];

1-(2'-deoxy-2'-fluoro-beta-D-arabinofuranosyl)-5-iodocytosine (FIAC);

1-(2'-deoxy-2'-fluoro-beta-D-arabinofuranosyl)-5-iodocytosine triphosphate (FIACTP);

1-(2'-deoxy-2'-fluoro-beta-D-arabinofuranosyl)-5-methyluracil (FMAU);

1-beta-D-ribofuranosyl-1,2,4-triazole-3-carboxamide;

2',3'-dideoxy-3'-fluoro-5-methyl-dexocytidine (FddMeCyt);

2',3'-dideoxy-3'-chloro-5-methyl-dexocytidine (CldMeCyt);

2',3'-dideoxy-3'-amino-5-methyl-dexocytidine (AddMeCyt);

2',3'-dideoxy-3'-fluoro-5-methyl-cytidine (FddMeCyt);

2',3'-dideoxy-3'-chloro-5-methyl-cytidine (CldMeCyt);

2',3'-dideoxy-3'-amino-5-methyl-cytidine (AddMeCyt);

2',3'-dideoxy-3'-fluorothymidine (FddThd);

2',3'-dideoxy-beta-L-5-fluorocytidine (beta-L-FddC);

2',3'-dideoxy-beta-L-5-thiacytidine;

2',3'-dideoxy-beta-L-5-cytidine (beta-L-ddC);

9-(1,3-dihydroxy-2-propoxymethyl)guanine;

2'-deoxy-3'-thia-5-fluorocytosine;

3'-amino-5-methyl-dexocytidine (AddMeCyt);

2-amino-1,9-[(2-hydroxymethyl-1-(hydroxymethyl)ethoxy]methyl]-6H-purin-6-one (gancyclovir);

2-[2-(2-amino-9H-purin-9y)ethyl]-1,3-propandil diacetate (famciclovir);

2-amino-1,9-dihydro-9-[(2-hydroxy-ethoxy)methyl]6H-purin-6-one (acyclovir);

9-(4-hydroxy-3-hydroxymethyl-but-1-yl)guanine (penciclovir);

9-(4-hydroxy-3-hydroxymethyl-but-1-yl)-6-deoxy-guanine, diacetate (famciclovir);

3'-azido-3'-deoxythymidine (AZT);

3'-chloro-5-methyl-dexocytidine (CldMeCyt);

9-(2-phosphonyl-methoxyethyl)-2',6'-diaminopurine-2',3'-dideoxyriboside;

9-(2-phosphonylmethoxyethyl)adenine (PMEA);

acyclovir triphosphate (ACVTP);

D-carbocyclic-2'-deoxyguanosine (CdG);

dideoxy-cytidine;

dideoxy-cytosine (ddC);

dideoxy-guanine (ddG);

dideoxy-inosine (ddI);

E-5-(2-bromovinyl)-2'-deoxyuridine triphosphate;

fluoro-arabinofuranosyl-iodouracil;

1-(2'-deoxy-2'-fluoro-1-beta-D-arabinofuranosyl)-5-iodo-uracil (FIAU);

stavudine;

9-beta-D-arabinofuranosyl-9H-purine-6-amine monohydrate (Ara-A);

9-beta-D-arabinofuranosyl-9H-purine-6-amine-5'-monophosphate monohydrate (Ara-AMP);

2-deoxy-3'-thia-5-fluorocytidine;

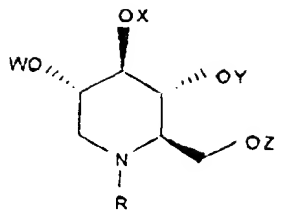
2',3'-dideoxy-guanine; and

2',3'-dideoxy-guanosine.

48. The method of claim 41, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of *N*-(n-nonyl-)-1,5-dideoxy-1,5-imino-D-glucitol or a pharmaceutically acceptable salt thereof, *N*-(n-nonyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate or a pharmaceutically acceptable salt thereof, and mixtures thereof; and

wherein said nucleoside or nucleotide antiviral compound is (-)-2'-deoxy-3'-thiocytidine-5'-triphosphate (3TC).

49. A method for treating a hepatitis B virus infection in a mammal, comprising administering to said mammal from about 0.1 mg/kg/day to about 100 mg/kg/day of at least one N-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof:



(I)

wherein R is selected from the group consisting of straight chain alkyl having a chain length of C_7 to C_{20}, branched chain alkyl having a chain length of C_3 to C_{20} in the main chain, alkoxyalkyl, arylalkyl, and cycloalkylalkyl, and

wherein W, X, Y and Z are each independently selected from the group consisting of hydrogen, alkanoyl, aroyl, and trifluoroalkanoyl; and

from about 0.1 mg/person/day to about 500 mg/person/day of a compound selected from the group consisting of a nucleoside antiviral compound, a nucleotide antiviral compound, and a mixture thereof.

50. The method of claim 49, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each hydrogen.

51. The method of claim 50, wherein R is nonyl.

52. The method of claim 49, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each alkanoyl.

53. The method of claim 52, wherein R is nonyl.

54. The method of claim 53, wherein said alkanoyl is butanoyl.

55. The method of claim 49, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of:

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-methyloctyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-methyloctyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol; and

N-(7,10,13-trioxa-n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol.

56. The method of claim 49, wherein said nucleoside or nucleotide antiviral compound is selected from the group consisting of:

(+)-cis-5-fluoro-1-[2-(hydroxy-methyl)-[1,3-oxathiolan-5-yl]cytosine;

(-)-2'-deoxy-3'-thiocytidine-5'-triphosphate (3TC);

(-)-cis-5-fluoro-1-[2-(hydroxy-methyl)-[1,3-oxathiolan-5-yl]cytosine (FTC);

(-)2',3', dideoxy-3'-thiacytidine [(-)-SddC];

1-(2'-deoxy-2'-fluoro-beta-D-arabinofuranosyl)-5-iodocytosine (FIAC);

1-(2'-deoxy-2'-fluoro-beta-D-arabinofuranosyl)-5-iodocytosine triphosphate (FIACTP);

1-(2'-deoxy-2'-fluoro-beta-D-arabinofuranosyl)-5-methyluracil (FMAU);

1-beta-D-ribofuranosyl-1,2,4-triazole-3 carboxamide;

2',3'-dideoxy-3'-fluoro-5-methyl-dexocytidine (FddMeCyt);

2',3'-dideoxy-3'-chloro-5-methyl-dexocytidine (CldMeCyt);

2',3'-dideoxy-3'-amino-5-methyl-dexocytidine (AddMeCyt);

2',3'-dideoxy-3'-fluoro-5-methyl-cytidine (FddMeCyt);

2',3'-dideoxy-3'-chloro-5-methyl-cytidine (CldMeCyt);

2',3'-dideoxy-3'-amino-5-methyl-cytidine (AddMeCyt);

2',3'-dideoxy-3'-fluorothymidine (FddThd);

2',3'-dideoxy-beta-L-5-fluorocytidine (beta-L-FddC);

2',3'-dideoxy-beta-L-5-thiacytidine;

2',3'-dideoxy-beta-L-5-cytidine (beta-L-ddC);

9-(1,3-dihydroxy-2-propoxymethyl)guanine;

2'-deoxy-3'-thia-5-fluorocytosine;

3'-amino-5-methyl-dexocytidine (AddMeCyt);

2-amino-1,9-[(2-hydroxymethyl-1-(hydroxymethyl)ethoxy]methyl]-6H-purin-6-one (gancyclovir);

2-[2-(2-amino-9H-purin-9y)ethyl]-1,3-propandil diacetate (famciclovir);

2-amino-1,9-dihydro-9-[(2-hydroxy-ethoxy)methyl]6H-purin-6-one (acyclovir);

9-(4-hydroxy-3-hydroxymethyl-but-1-yl)guanine (penciclovir);

9-(4-hydroxy-3-hydroxymethyl-but-1-yl)-6-deoxy-guanine, diacetate (famciclovir);

3'-azido-3'-deoxythymidine (AZT);

3'-chloro-5-methyl-dexocytidine (CldMeCyt);

9-(2-phosphonyl-methoxyethyl)-2',6'-diaminopurine-2',3'-dideoxyriboside;

9-(2-phosphonylmethoxyethyl)adenine (PMEA);

acyclovir triphosphate (ACVTP);

D-carbocyclic-2'-deoxyguanosine (CdG);

dideoxy-cytidine;

dideoxy-cytosine (ddC);

dideoxy-guanine (ddG);

dideoxy-inosine (ddI);

E-5-(2-bromovinyl)-2'-deoxyuridine triphosphate;

fluoro-arabinofuranosyl-iodouracil;

1-(2'-deoxy-2'-fluoro-1-beta-D-arabinofuranosyl)-5-iodo-uracil (FIAU);

stavudine;

9-beta-D-arabinofuranosyl-9H-purine-6-amine monohydrate (Ara-A);

9-beta-D-arabinofuranosyl-9H-purine-6-amine-5'-monophosphate monohydrate (Ara-AMP);

2-deoxy-3'-thia-5-fluorocytidine;

2',3'-dideoxy-guanine; and

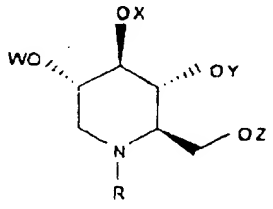
2',3'-dideoxy-guanosine.

57. The method of claim 49, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of *N*-(n-nonyl-)-1,5-dideoxy-1,5-imino-D-glucitol or a pharmaceutically acceptable salt thereof, *N*-(n-nonyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate or a pharmaceutically acceptable salt thereof, and mixtures thereof; and

wherein said nucleoside or nucleotide antiviral compound is (-)-2'-deoxy-3'-thiocytidine-5'-triphosphate (3TC).

58. A method for treating a hepatitis B virus infection in a human patient, comprising administering to said human patient from about 0.1 mg/kg/day to about 100 mg/kg/day of an *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound selected from the group consisting *N*-(n-nonyl-)-1,5-dideoxy-1,5-imino-D-glucitol or a pharmaceutically acceptable salt thereof, *N*-(n-nonyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate or a pharmaceutically acceptable salt thereof, and mixtures thereof, and from about 0.1 mg/person/day to about 500 mg/person/day of (-)-2'-deoxy-3'-thiocytidine-5'-triphosphate.

59. A method for treating a hepatitis virus infection in a mammal, comprising administering to said mammal an antiviral effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof:



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substantially exclusive of the administration of an antiviral composition comprising a nucleoside, a nucleotide, an immunomodulator, or an immunostimulant,

wherein R is selected from the group consisting of straight chain alkyl having a chain length of C_7 to C_{20}, branched chain alkyl having a chain length of C_3 to C_{20} in the main chain, alkoxyalkyl, arylalkyl, and cycloalkylalkyl, and

wherein W, X, Y and Z are each independently selected from the group consisting of hydrogen, alkanoyl, aroyl, and trifluoroalkanoyl.

60. The method of claim 59, further comprising administering said at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or pharmaceutically acceptable salt thereof in combination with a pharmaceutically acceptable carrier, excipient, or diluent.

61. The method of claim 59, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each hydrogen.

62. The method of claim 61, wherein R is nonyl.

63. The method of claim 59, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each alkanoyl.

64. The method of claim 63, wherein R is nonyl.

65. The method of claim 64, wherein said alkanoyl is butanoyl.

66. The method of claim 59, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of:

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate
N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-methyloctyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-methyloctyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

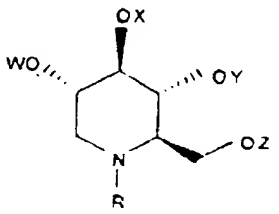
N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol; and

N-(7,10,13-trioxa-n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol.

67. The method of claim 59, wherein said pharmaceutically acceptable salt is selected from the group consisting of acetate, adipate, alginate, citrate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, camphorate, camphorsulfonate, digluconate, cyclopentanepropionate, dodecylsulfate, ethanesulfonate, glucoheptanoate,

glycerophosphate, hemisulfate, heptanoate, hexanoate, fumarate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxy-ethanesulfonate, lactate, maleate, methanesulfonate, nicotinate, 2-naphthalenesulfonate, oxalate, palmoate, pectinate, persulfate, 3-phenylpropionate, picrate, pivalate, propionate, succinate, tartrate, thiocyanate, tosylate, mesylate, and undecanoate.

68. A method for treating a hepatitis virus infection in a mammal, comprising administering to said mammal an antiviral effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof:



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substantially exclusive of the administration of antiviral compounds other than compounds of Formula I,

wherein R is selected from the group consisting of straight chain alkyl having a chain length of C_7 to C_{20}, branched chain alkyl having a chain length of C_3 to C_{20} in the main chain, alkoxyalkyl, arylalkyl, and cycloalkylalkyl, and

wherein W, X, Y and Z are each independently selected from the group consisting of hydrogen, alkanoyl, aroyl, and trifluoroalkanoyl.

69. The method of claim 68, further comprising administering said at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or

pharmaceutically acceptable salt thereof in combination with a pharmaceutically acceptable carrier, excipient, or diluent.

70. The method of claim 68, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each hydrogen.

71. The method of claim 70, wherein R is nonyl.

72. The method of claim 68, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each alkanoyl.

73. The method of claim 72, wherein R is nonyl.

74. The method of claim 73, wherein said alkanoyl is butanoyl.

75. The method of claim 68, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of:

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-methyloctyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-methyloctyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5 imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

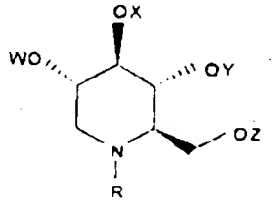
N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-*D*-glucitol, tetraacetate;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol; and

N-(7,10,13-trioxa-n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol.

76. The method of claim 68, wherein said pharmaceutically acceptable salt is selected from the group consisting of acetate, adipate, alginate, citrate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, camphorate, camphorsulfonate, digluconate, cyclopentanepropionate, dodecylsulfate, ethanesulfonate, glucoheptanoate, glycerophosphate, hemisulfate, heptanoate, hexanoate, fumarate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxy-ethanesulfonate, lactate, maleate, methanesulfonate, nicotinate, 2-naphthalenesulfonate, oxalate, palmoate, pectinate, persulfate, 3-phenylpropionate, picrate, pivalate, propionate, succinate, tartrate, thiocyanate, tosylate, mesylate, and undecanoate.

77. A pharmaceutical composition, comprising an antiviral effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof:



(I)

wherein R is selected from the group consisting of straight chain alkyl having a chain length of C_7 to C_{20}, branched chain alkyl having a chain length of C_3 to C_{20} in the main chain, alkoxyalkyl, arylalkyl, and cycloalkylalkyl, and

wherein W, X, Y and Z are each independently selected from the group consisting of hydrogen, alkanoyl, aroyl, and trifluoroalkanoyl; and

a pharmaceutically acceptable carrier, excipient,or diluent.

78. The pharmaceutical composition of claim 77, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each hydrogen.

79. The pharmaceutical composition of claim 78, wherein R is nonyl.

80. The pharmaceutical composition of claim 77, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each alkanoyl.

81. The pharmaceutical composition of claim 80, wherein R is nonyl.

82. The pharmaceutical composition of claim 81, wherein said alkanoyl is butanoyl.

83. The pharmaceutical composition of claim 77, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of:

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-methyloctyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-methyloctyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

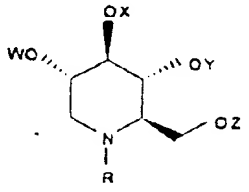
N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol; and

N-(7,10,13-trioxa-n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol.

84. The pharmaceutical composition of claim 77, wherein said pharmaceutically acceptable salt is selected from the group consisting of acetate, adipate, alginate, citrate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, camphorate, camphorsulfonate, digluconate, cyclopentanepropionate, dodecylsulfate, ethanesulfonate, glucoheptanoate, glycerophosphate, hemisulfate, heptanoate, hexanoate, fumarate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxy-ethanesulfonate, lactate, maleate, methanesulfonate, nicotinate, 2-naphthalenesulfonate, oxalate, palmoate, pectinate, persulfate, 3-phenylpropionate, picrate, pivalate, propionate, succinate, tartrate, thiocyanate, tosylate, mesylate, and undecanoate.

85. A pharmaceutical composition, consisting essentially of an antiviral effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof:



(I)

wherein R is selected from the group consisting of straight chain alkyl having a chain length of C_7 to C_{20}, branched chain alkyl having a chain length of C_3 to C_{20} in the main chain, alkoxyalkyl, arylalkyl, and cycloalkylalkyl, and

wherein W, X, Y and Z are each independently selected from the group consisting of hydrogen, alkanoyl, aroyl, and trifluoroalkanoyl; and

a pharmaceutically acceptable carrier, diluent, or excipient.

86. The pharmaceutical composition of claim 85, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each hydrogen.

87. The pharmaceutical composition of claim 86, wherein R is nonyl.

88. The pharmaceutical composition of claim 85, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each alkanoyl.

89. The pharmaceutical composition of claim 88, wherein R is nonyl.

90. The pharmaceutical composition of claim 89, wherein said alkanoyl is butanoyl.

91. The pharmaceutical composition of claim 85, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of:

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-methyloctyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-methyloctyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

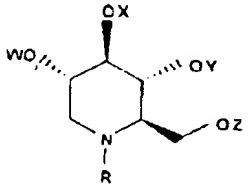
N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol; and

N-(7,10,13-trioxa-n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol.

92. The method of claim 85, wherein said pharmaceutically acceptable salt is selected from the group consisting of acetate, adipate, alginate, citrate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, camphorate, camphorsulfonate, digluconate, cyclopentanepropionate, dodecylsulfate, ethanesulfonate, glucoheptanoate, glycerophosphate, hemisulfate, heptanoate, hexanoate, fumarate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxy-ethanesulfonate, lactate, maleate, methanesulfonate, nicotinate, 2-naphthalenesulfonate, oxalate, palmoate, pectinate, persulfate, 3-phenylpropionate, picrate, pivalate, propionate, succinate, tartrate, thiocyanate, tosylate, mesylate, and undecanoate.

93. A pharmaceutical composition, comprising an antiviral effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof:



(I)

substantially free of a nucleoside, nucleotide, immunomodulator, or immunostimulant,

wherein R is selected from the group consisting of straight chain alkyl having a chain length of C_7 to C_{20}, branched chain alkyl having a chain length of C_3 to C_{20} in the main chain, alkoxyalkyl, arylalkyl, and cycloalkylalkyl, and

wherein W, X, Y and Z are each independently selected from the group consisting of hydrogen, alkanoyl, aroyl, and trifluoroalkanoyl; and

a pharmaceutically acceptable, carrier, diluent, or excipient.

94. The pharmaceutical composition of claim 93, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each hydrogen.

95. The pharmaceutical composition of claim 94, wherein R is nonyl.

96. The pharmaceutical composition of claim 93, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each alkanoyl.

97. The pharmaceutical composition of claim 96, wherein R is nonyl.

98. The pharmaceutical composition of claim 97, wherein said alkanoyl is butanoyl.

99. The pharmaceutical composition of claim 93, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of:

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate
N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(7-methyloctyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-methyloctyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

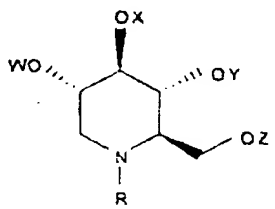
N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol; and

N-(7,10,13-trioxa-n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol.

100. The pharmaceutical composition of claim 93, wherein said pharmaceutically acceptable salt is selected from the group consisting of acetate, adipate, alginate, citrate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, camphorate, camphorsulfonate, digluconate, cyclopentanepropionate, dodecylsulfate, ethanesulfonate, glucoheptanoate, glycerophosphate, hemisulfate, heptanoate, hexanoate, fumarate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxy-ethanesulfonate, lactate, maleate, methanesulfonate, nicotinate, 2-naphthalenesulfonate, oxalate, palmoate, pectinate, persulfate, 3-phenylpropionate, picrate, pivalate, propionate, succinate, tartrate, thiocyanate, tosylate, mesylate, and undecanoate.

101. A pharmaceutical composition, comprising an antiviral effective amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof:



15 (I)

substantially free of antiviral compounds other than compounds of Formula I,

wherein R is selected from the group consisting of straight chain alkyl having a chain length of C_7 to C_{20}, branched chain alkyl having a chain length of C_3 to C_{20} in the main chain, alkoxyalkyl, arylalkyl, and cycloalkylalkyl, and

20 wherein W, X, Y and Z are each independently selected from the group consisting of hydrogen, alkanoyl, aroyl, and trifluoroalkanoyl; and

a pharmaceutically acceptable, carrier, diluent, or excipient.

102. The pharmaceutical composition of claim 101, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each hydrogen.

103. The pharmaceutical composition of claim 102, wherein R is nonyl.

104. The pharmaceutical composition of claim 101, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each alkanoyl.

105. The pharmaceutical composition of claim 104, wherein R is nonyl.

106. The pharmaceutical composition of claim 105, wherein said alkanoyl is butanoyl.

107. The pharmaceutical composition of claim 101, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of:

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol;

5 *N*-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-methyloctyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-methyloctyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

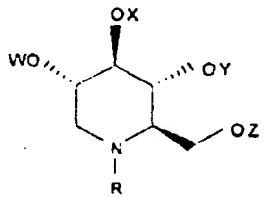
N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol; and

N-(7,10,13-trioxa-n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol.

108. The pharmaceutical composition of claim 101, wherein said pharmaceutically acceptable salt is selected from the group consisting of acetate, adipate, alginate, citrate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, camphorate, camphorsulfonate, digluconate, cyclopentanepropionate, dodecylsulfate, ethanesulfonate, glucoheptanoate, glycerophosphate, hemisulfate, heptanoate, hexanoate, fumarate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxy-ethanesulfonate, lactate, maleate, methanesulfonate, nicotinate, 2-naphthalenesulfonate, oxalate, palmoate, pectinate, persulfate, 3-phenylpropionate, picrate, pivalate, propionate, succinate, tartrate, thiocyanate, tosylate, mesylate, and undecanoate.

109. A composition, comprising at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof:



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wherein R is selected from the group consisting of straight chain alkyl having a chain length of C_7 to C_{20}, branched chain alkyl having a chain length of C_3 to C_{20} in the main chain, alkoxyalkyl, arylalkyl, and cycloalkylalkyl, and

wherein W, X, Y and Z are each independently selected from the group consisting of hydrogen, alkanoyl, aroyl, and trifluoroalkanoyl; and

an antiviral compound selected from the group consisting of a nucleoside antiviral compound, a nucleotide antiviral compound, an immunomodulator, an immunostimulant, and mixtures thereof.

110. The composition of claim 109, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each hydrogen.

111. The composition of claim 110, wherein R is nonyl.

112. The composition of claim 109, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each alkanoyl.

113. The composition of claim 112, wherein R is nonyl.

114. The composition of claim 113, wherein said alkanoyl is butanoyl.

115. The composition of claim 109, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of:

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tetradecyl)-1,5-didcoxy-1,5-imino-D-glucitol;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-hexadecyl)-1,5-didcoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-methyloctyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-methyloctyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy 1,5-imino-D-glucitol, tetrabutyrate;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol; and

N-(7,10,13-trioxa-n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol.

116. The composition of claim 109, wherein said nucleoside or nucleotide antiviral compound is selected from the group consisting of:

(+)-cis-5-fluoro-1-[2-(hydroxy-methyl)-[1,3-oxathiolan-5-yl]cytosine;

(-)-2'-deoxy-3'-thiocytidine-5'-triphosphate (3TC);

(-)-cis-5-fluoro-1-[2-(hydroxy-methyl)-[1,3-oxathiolan-5-yl]cytosine (FTC);

(-)2',3', didcoxy-3'-thiacytidine [(-)-SddC];

1-(2'-deoxy-2'-fluoro-beta-D-arabinofuranosyl)-5-iodocytosine (FIAC);

1-(2'-deoxy-2'-fluoro-beta-D-arabinofuranosyl)-5-iodocytosine triphosphate (FIACTP);

1-(2'-deoxy-2'-fluoro-beta-D-arabinofuranosyl)-5-methyluracil (FMAU);

1-beta-D-ribofuranosyl-1,2,4-triazole-3-carboxamide;

2',3'-dideoxy-3'-fluoro-5-methyl-dexocytidine (FddMeCyt);

2',3'-dideoxy-3'-chloro-5-methyl-dexocytidine (CldMeCyt);

2',3'-dideoxy-3'-amino-5-methyl-dexocytidine (AddMeCyt);

2',3'-dideoxy-3'-fluoro-5-methyl-cytidine (FddMeCyt);

2',3'-dideoxy-3'-chloro-5-methyl-cytidine (CldMeCyt);

2',3'-dideoxy-3'-amino-5-methyl-cytidine (AddMeCyt);

2',3'-dideoxy-3'-fluorothymidine (FddThd);

2',3'-dideoxy-beta-L-5-fluorocytidine (beta-L-FddC);

2',3'-dideoxy-beta-L-5-thiacytidine;

2',3'-dideoxy-beta-L-5-cytidine (beta-L-ddC);

9-(1,3-dihydroxy-2-propoxymethyl)guanine;

2'-deoxy-3'-thia-5-fluorocytosine;

3'-amino-5-methyl-dexocytidine (AddMeCyt);

2-amino-1,9-[(2-hydroxymethyl-1-(hydroxymethyl)ethoxy]methyl]-6H-purin-6-one (gancyclovir);

2-[2-(2-amino-9H-purin-9y)ethyl]-1,3-propandil diacetate (famciclovir);

2-amino-1,9-dihydro-9-[(2-hydroxy-ethoxy)methyl]6H-purin-6-one (acyclovir);

9-(4-hydroxy-3-hydroxymethyl-but-1-yl)guanine (penciclovir);

9-(4-hydroxy-3-hydroxymethyl-but-1-yl)-6-deoxy-guanine, diacetate (famciclovir);

3'-azido-3'-deoxythymidine (AZT);

3'-chloro-5-methyl-dexocytidine (CldMeCyt);

9-(2-phosphonyl-methoxyethyl)-2',6'-diaminopurine-2',3'-dideoxyriboside;

9-(2-phosphonylmethoxyethyl)adenine (PMEA);

acyclovir triphosphate (ACVTP);

D-carbocyclic-2'-deoxyguanosine (CdG);

dideoxy-cytidine;

dideoxy-cytosine (ddC);

dideoxy-guanine (ddG);

dideoxy-inosine (ddI);

E-5-(2-bromovinyl)-2'-deoxyuridine triphosphate;

fluoro-arabinofuranosyl-iodouracil;

1-(2'-deoxy-2'-fluoro-1-beta-D-arabinofuranosyl)-5-iodo-uracil (FIAU);

stavudine;

9-beta-D-arabinofuranosyl-9H-purine-6-amine monohydrate (Ara-A);

9-beta-D-arabinofuranosyl-9H-purine-6-amine-5'-monophosphate monohydrate (Ara-AMP);

2-deoxy-3'-thia-5-fluorocytidine;

2',3'-dideoxy-guanine; and

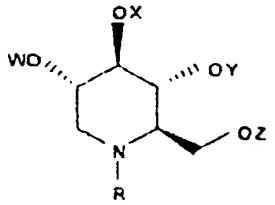
2',3'-dideoxy-guanosine.

117. The composition of claim 109, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of *N*-(n-nonyl-)-1,5-dideoxy-1,5-imino-D-glucitol or a pharmaceutically acceptable salt thereof, *N*-(n-nonyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate or a pharmaceutically acceptable salt thereof, and mixtures thereof; and

wherein said nucleoside or nucleotide antiviral compound is (-)-2'-deoxy-3'-thiocytidine-5'-triphosphate (3TC).

118. A pharmaceutical composition, comprising:

a first amount of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof:



(I)

wherein R is selected from the group consisting of straight chain alkyl having a chain length of C_7 to C_{20}, branched chain alkyl having a chain length of C_3 to C_{20} in the main chain, alkoxyalkyl, arylalkyl, and cycloalkylalkyl, and

wherein W, X, Y and Z are each independently selected from the group consisting of hydrogen, alkanoyl, aroyl, and trifluoroalkanoyl;

a second amount of an antiviral compound selected from the group consisting of a nucleoside antiviral compound, a nucleotide antiviral compound, an immunomodulator, and immunostimulant, and mixtures thereof; and

a pharmaceutically acceptable carrier, diluent, or excipient,

wherein said first and second amounts of said compounds together comprise an antiviral effective amount of said compounds.

119. The pharmaceutical composition of claim 118, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each hydrogen.

120. The pharmaceutical composition of claim 119, wherein R is nonyl.

121. The pharmaceutical composition of claim 118, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each alkanoyl.

122. The pharmaceutical composition of claim 121, wherein R is nonyl.

123. The pharmaceutical composition of claim 122, wherein said alkanoyl is butanoyl.

124. The pharmaceutical composition of claim 118, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of:

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-methyloctyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-methyloctyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol; and

N-(7,10,13-trioxa-n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol.

125. The pharmaceutical composition of claim 118, wherein said nucleoside or nucleotide antiviral compound is selected from the group consisting of:

(+)-cis-5-fluoro-1-[2-(hydroxy-methyl)-[1,3-oxathiolan-5-yl]cytosine;

(-)-2'-deoxy-3'-thiocytidine-5'-triphosphate (3TC);

(-)-cis-5-fluoro-1-[2-(hydroxy-methyl)-[1,3-oxathiolan-5-yl]cytosine (FTC);

(-)2',3', dideoxy-3'-thiacytidine [(-)-SddC];

1-(2'-deoxy-2'-fluoro-beta-D-arabinofuranosyl)-5-iodocytosine (FIAC);

1-(2'-deoxy-2'-fluoro-beta-D-arabinofuranosyl)-5-iodocytosine triphosphate (FIACTP);

1-(2'-deoxy-2'-fluoro-beta-D-arabinofuranosyl)-5-methyluracil (FMAU);

1-beta-D-ribofuranosyl-1,2,4-triazole-3-carboxamide;

2',3'-dideoxy-3'-fluoro-5-methyl-dexocytidine (FddMeCyt);

2',3'-dideoxy-3'-chloro-5-methyl-dexocytidine (CldMeCyt);

2',3'-dideoxy-3'-amino-5-methyl-dexocytidine (AddMeCyt);

2',3'-dideoxy-3'-fluoro-5-methyl-cytidine (FddMeCyt);

2',3'-dideoxy-3'-chloro-5-methyl-cytidine (CldMeCyt);

2',3'-dideoxy-3'-amino-5-methyl-cytidine (AddMeCyt);

2',3'-dideoxy-3'-fluorothymidine (FddThd);

2',3'-dideoxy-beta-L-5-fluorocytidine (beta-L-FddC);

2',3'-dideoxy-beta-L-5-thiacytidine;

2',3'-dideoxy-beta-L-5-cytidine (beta-L-ddC);

9-(1,3-dihydroxy-2-propoxymethyl)guanine;

2'-deoxy-3'-thia-5-fluorocytosine;

3'-amino-5-methyl-dexocytidine (AddMeCyt);

2-amino-1,9-[(2-hydroxymethyl-1-(hydroxymethyl)ethoxy]methyl]-6H-purin-6-one (gancyclovir);

2-[2-(2-amino-9H-purin-9y)ethyl]-1,3-propandil diacetate (famciclovir);

2-amino-1,9-dihydro-9-[(2-hydroxy-ethoxy)methyl]6H-purin-6-one (acyclovir);

9-(4-hydroxy-3-hydroxymethyl-but-1-yl)guanine (penciclovir);

9-(4-hydroxy-3-hydroxymethyl-but-1-yl)-6-deoxy-guanine, diacetate (famciclovir);

3'-azido-3'-deoxythymidine (AZT);

3'-chloro-5-methyl-dexocytidine (CldMeCyt);

9-(2-phosphonyl-methoxyethyl)-2',6'-diaminopurine-2',3'-dideoxyriboside;

9-(2-phosphonylmethoxyethyl)adenine (PMEA);

acyclovir triphosphate (ACVTP);

D-carbocyclic-2'-deoxyguanosine (CdG);

dideoxy-cytidine;

dideoxy-cytosine (ddC);

dideoxy-guanine (ddG);

dideoxy-inosine (ddI);

E-5-(2-bromovinyl)-2'-deoxyuridine triphosphate;

fluoro-arabinofuranosyl-iodouracil;

1-(2'-deoxy-2'-fluoro-1-beta-D-arabinofuranosyl)-5-iodo-uracil (FIAU);

stavudine;

9-beta-D-arabinofuranosyl-9H-purine-6-amine monohydrate (Ara-A);

9-beta-D-arabinofuranosyl-9H-purine-6-amine-5'-monophosphate monohydrate (Ara-AMP);

2-deoxy-3'-thia-5-fluorocytidine;

2',3'-dideoxy-guanine; and

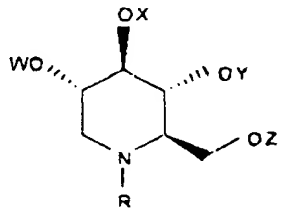
2',3'-dideoxy-guanosine.

126. The pharmaceutical composition of claim 118, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of *N*-(n-nonyl-)-1,5-dideoxy-1,5-imino-D-glucitol or a pharmaceutically acceptable salt thereof, *N*-(n-nonyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate or a pharmaceutically acceptable salt thereof, and mixtures thereof; and

wherein said nucleoside or nucleotide antiviral compound is (-)-2'-deoxy-3'-thiocytidine-5'-triphosphate (3TC).

127. A pharmaceutical composition for treating a hepatitis B virus infection in a mammal, comprising:

from about 0.1 mg to about 100 mg of at least one *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I or a pharmaceutically acceptable salt thereof:



(I)

wherein R is selected from the group consisting of straight chain alkyl having a chain length of C_7 to C_{20}, branched chain alkyl having a chain length of C_3 to C_{20} in the main chain, alkoxyalkyl, arylalkyl, and cycloalkylalkyl, and

wherein W, X, Y and Z are each independently selected from the group consisting of hydrogen, alkanoyl, aroyl, and trifluoroalkanoyl;

from about 0.1 mg to about 500 mg of a compound selected from the group consisting of a nucleoside antiviral compound, a nucleotide antiviral, and mixtures thereof; and

a pharmaceutically acceptable carrier, diluent, or excipient.

128. The pharmaceutical composition of claim 127, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each hydrogen.

129. The pharmaceutical composition of claim 128, wherein R is nonyl.

130. The pharmaceutical composition of claim 127, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each alkanoyl.

131. The pharmaceutical composition of claim 130, wherein R is nonyl.

132. The pharmaceutical composition of claim 131, wherein said alkanoyl is butanoyl.

133. The pharmaceutical composition of claim 127, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of:

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino D-glucitol;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-methyloctyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-methyldecyl)-1,5-dideoxy 1,5-imino-D-glucitol;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-methyloctyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol; and

N-(7,10,13-trioxa-n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol.

134. The pharmaceutical composition of claim 127, wherein said nucleoside or nucleotide antiviral compound is selected from the group consisting of:

(+)-cis-5-fluoro-1-[2-(hydroxy-methyl)-[1,3-oxathiolan-5-yl]cytosine;

(-)-2'-deoxy-3'-thiocytidine-5'-triphosphate (3TC);

(-)-cis-5-fluoro-1-[2-(hydroxy-methyl)-[1,3-oxathiolan-5-yl]cytosine (FTC);

(-)2',3', dideoxy-3'-thiacytidine [(-)-SddC];

1-(2'-deoxy-2'-fluoro-beta-D-arabinofuranosyl)-5-iodocytosine (FIAC);

1-(2'-deoxy-2'-fluoro-beta-D-arabinofuranosyl)-5-iodocytosine triphosphate (FIACTP);

1-(2'-deoxy-2'-fluoro-beta-D-arabinofuranosyl)-5-methyluracil (FMAU);

1-beta-D-ribofuranosyl-1,2,4-triazole-3-carboxamide;

2',3'-dideoxy-3'-fluoro-5-methyl-dexocytidine (FddMeCyt);

2',3'-dideoxy-3'-chloro-5-methyl-dexocytidine (CldMeCyt);

2',3'-dideoxy-3'-amino-5-methyl-dexocytidine (AddMeCyt);

2',3'-dideoxy-3'-fluoro-5-methyl-cytidine (FddMeCyt);

2',3'-dideoxy-3'-chloro-5-methyl-cytidine (CldMeCyt);

2',3'-dideoxy-3'-amino-5-methyl-cytidine (AddMeCyt);

2',3'-dideoxy-3'-fluorothymidine (FddThd);

2',3'-dideoxy-beta-L-5-fluorocytidine (beta-L-FddC);

2',3'-dideoxy-beta-L-5-thiacytidine;

2',3'-dideoxy-beta-L-5-cytidine (beta-L-ddC);

9-(1,3-dihydroxy-2-propoxymethyl)guanine;

2'-deoxy-3'-thia-5-fluorocytosine;

3'-amino-5-methyl-dexocytidine (AddMeCyt);

2-amino-1,9-[(2-hydroxymethyl-1-(hydroxymethyl)ethoxy]methyl]-6H-purin-6-one (gancyclovir);

2-[2-(2-amino-9H-purin-9y)ethyl]-1,3-propandil diacetate (famciclovir);

2-amino-1,9-dihydro-9-[(2-hydroxy-ethoxy)methyl]6H-purin-6-one (acyclovir);

9-(4-hydroxy-3-hydroxymethyl-but-1-yl)guanine (penciclovir);

9-(4-hydroxy-3-hydroxymethyl-but-1-yl)-6-deoxy-guanine, diacetate (famciclovir);

3'-azido-3'-deoxythymidine (AZT);

3'-chloro-5-methyl-dexocytidine (CldMeCyt);

9-(2-phosphonyl-methoxyethyl)-2',6'-diaminopurine-2',3'-dideoxyriboside;

9-(2-phosphonylmethoxyethyl)adenine (PMEA);

acyclovir triphosphate (ACVTP);

D-carbocyclic-2'-deoxyguanosine (CdG);

dideoxy-cytidine;

didcoxy-cytosine (ddC);

dideoxy-guanine (ddG);

didcoxy-inosine (ddI);

E-5-(2-bromovinyl)-2'-deoxyuridine triphosphate;

fluoro-arabinofuranosyl-iodouracil;

1-(2'-deoxy-2'-fluoro-1-beta-D-arabinofuranosyl)-5-iodo-uracil (FIAU);

stavudine;

9-beta-D-arabinofuranosyl-9H-purine-6-amine monohydrate (Ara-A);

9-beta-D-arabinofuranosyl-9H-purine-6-amine-5'-monophosphate monohydrate (Ara-AMP);

2-deoxy-3'-thia-5-fluorocytidine;

2',3'-dideoxy-guanine; and

2',3'-dideoxy-guanosine.

135. The pharmaceutical composition of claim 127, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of *N*-(n-nonyl-)-1,5-dideoxy-1,5-imino-D-glucitol or a pharmaceutically acceptable salt thereof, *N*-(n-nonyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate or a pharmaceutically acceptable salt thereof, and mixtures thereof; and

wherein said nucleoside or nucleotide antiviral compound is (-)-2'-deoxy-3'-thiocytidine-5'-triphosphate (3TC).

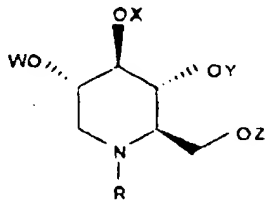
136. A pharmaceutical composition for treating a hepatitis B virus infection in a human patient, comprising:

from about 0.1 mg to about 100 mg of an *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound selected from the group consisting of *N*-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol or a pharmaceutically acceptable salt thereof, *N*-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate or a pharmaceutically acceptable salt thereof, and mixtures thereof;

from about 0.1 mg to about 500 mg of (-)-2'-deoxy-3'-thiocytidine-5'-triphosphate; and

a pharmaceutically acceptable carrier, diluent, or excipient.

137. A salt, comprising an *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound of Formula I:



(I)

wherein R is selected from the group consisting of straight chain alkyl having a chain length of C_7 to C_{20}, branched chain alkyl having a chain length of C_3 to C_{20} in the main chain, alkoxyalkyl, arylalkyl, and cycloalkylalkyl, and

wherein W, X, Y and Z are each independently selected from the group consisting of hydrogen, alkanoyl, aroyl, and trifluoroalkanoyl; and

a compound selected from the group consisting of a nucleoside having an acidic moiety and a nucleotide.

138. The salt of claim 137, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each hydrogen.

139. The salt of claim 138, wherein R is nonyl.

140. The salt of claim 137, wherein R is straight chain alkyl having a chain length of C_7 to C_{20}, and W, X, Y, and Z are each alkanoyl.

141. The salt of claim 140, wherein R is nonyl.

142. The salt of claim 141, wherein said alkanoyl is butanoyl.

143. The salt of claim 137, wherein said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of:

N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(n-heptyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate
N-(n-octyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-undecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-dodecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-tridecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-pentadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-hexadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-heptadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-octadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-nonadecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(n-eicosyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;
N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(7-methyloctyl)-1,5-dideoxy-1,5-imino-D-glucitol;
N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(2-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-ethylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(5-methylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-propylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-pentylpentylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-butylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-methyloctyl-)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(8-methylnonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(9-methyldecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(10-methylundecyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-cyclohexylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(4-cyclohexylbutyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(2-cyclohexylethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-cyclohexylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(1-phenylmethyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(3-(4-methyl)-phenylpropyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(6-phenylhexyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate;

N-(7-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(9-oxa-n-decyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(7-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetraacetate;

N-(3-oxa-n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol; and

N-(7,10,13-trioxa-n-tetradecyl)-1,5-dideoxy-1,5-imino-D-glucitol.

144. The salt of claim 137, wherein said nucleoside having an acidic moiety is selected from the group consisting of compounds of Formula II, III, IV, V, and VI.

145. The salt of claim 137, wherein said nucleotide is selected from the group consisting of compounds of Formula II, III, IV, V, and VI.

146. The salt of claim 145, wherein said nucleotide is selected from the group consisting of:

(-)-2'-deoxy-3'-thiocytidine-5'-triphosphate (3TC);

1-(2'-deoxy-2'-fluoro-beta-D-arabinofuranosyl)-5-iodocytosine triphosphate (FIACTP);

acyclovir triphosphate (ACVTP);

E-5-(2-bromovinyl)-2'-deoxyuridine triphosphate; and

9-beta-D-arabinofuranosyl-9H-purine-6-amine-5'-monophosphate monohydrate (Ara-AMP).

147. The salt of claim 137, wherein:

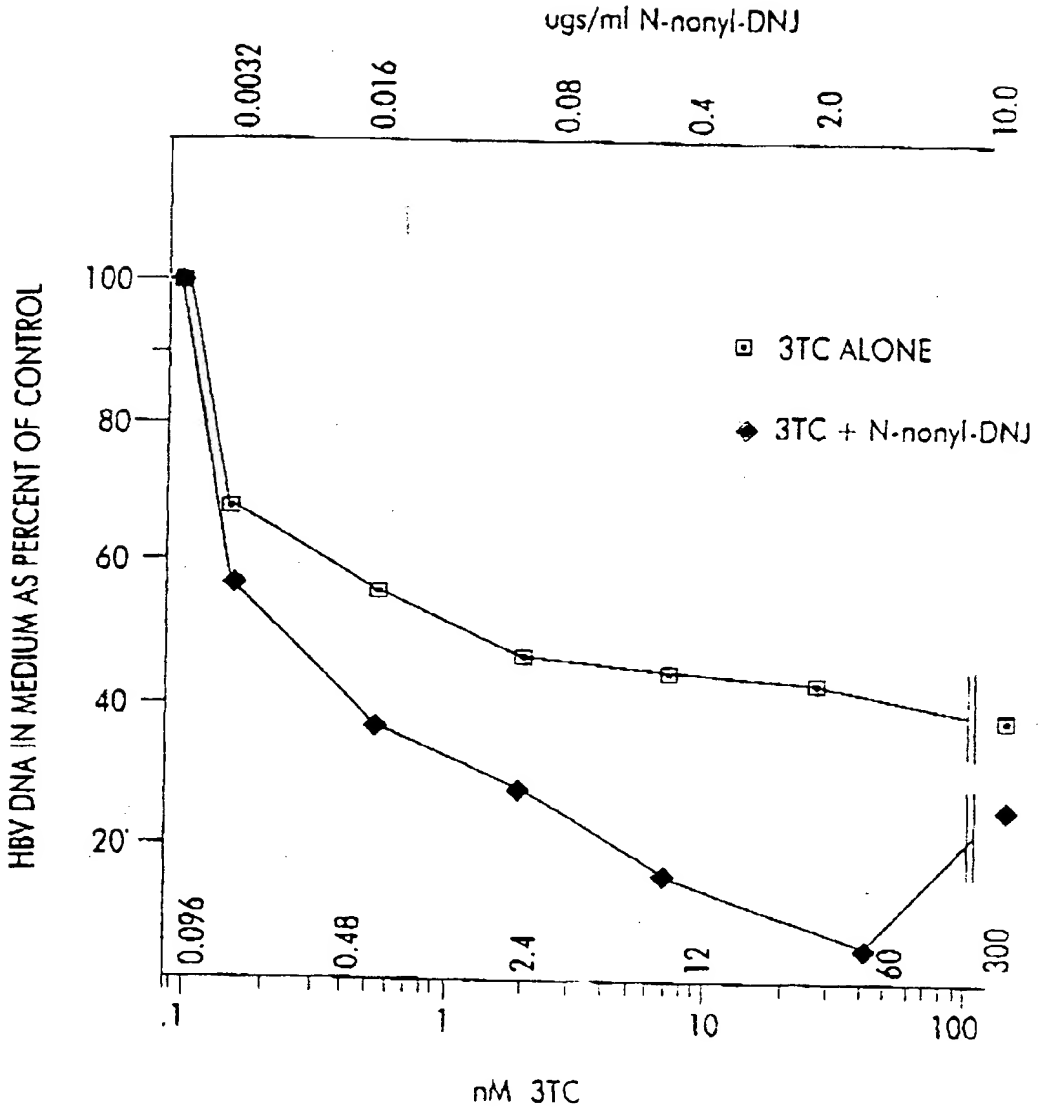
said *N*-substituted-1,5-dideoxy-1,5-imino-D-glucitol compound is selected from the group consisting of *N*-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol and *N*-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol, tetrabutyrate; and

said nucleotide is (-)-2'-deoxy-3'-thiocytidine-5'-triphosphate.

148. A method, comprising reacting *N*-(n-nonyl)-1,5-dideoxy-1,5-imino-D-glucitol and (-)-2'-deoxy-3'-thiocytidine-5'-triphosphate under salt-forming conditions.

149. A salt formed by the method of claim 148.

FIG.1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0.016
0.08
0.4
2.0
10.0
HBV DNA IN MEDIUM AS PERCENT OF CONTROL
100
80
60
40
20
3TC ALONE
3TC + N-nonyl-DNJ
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0.48
2.4
12
60
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.1
1
10
100
nM 3TC

FIG.2

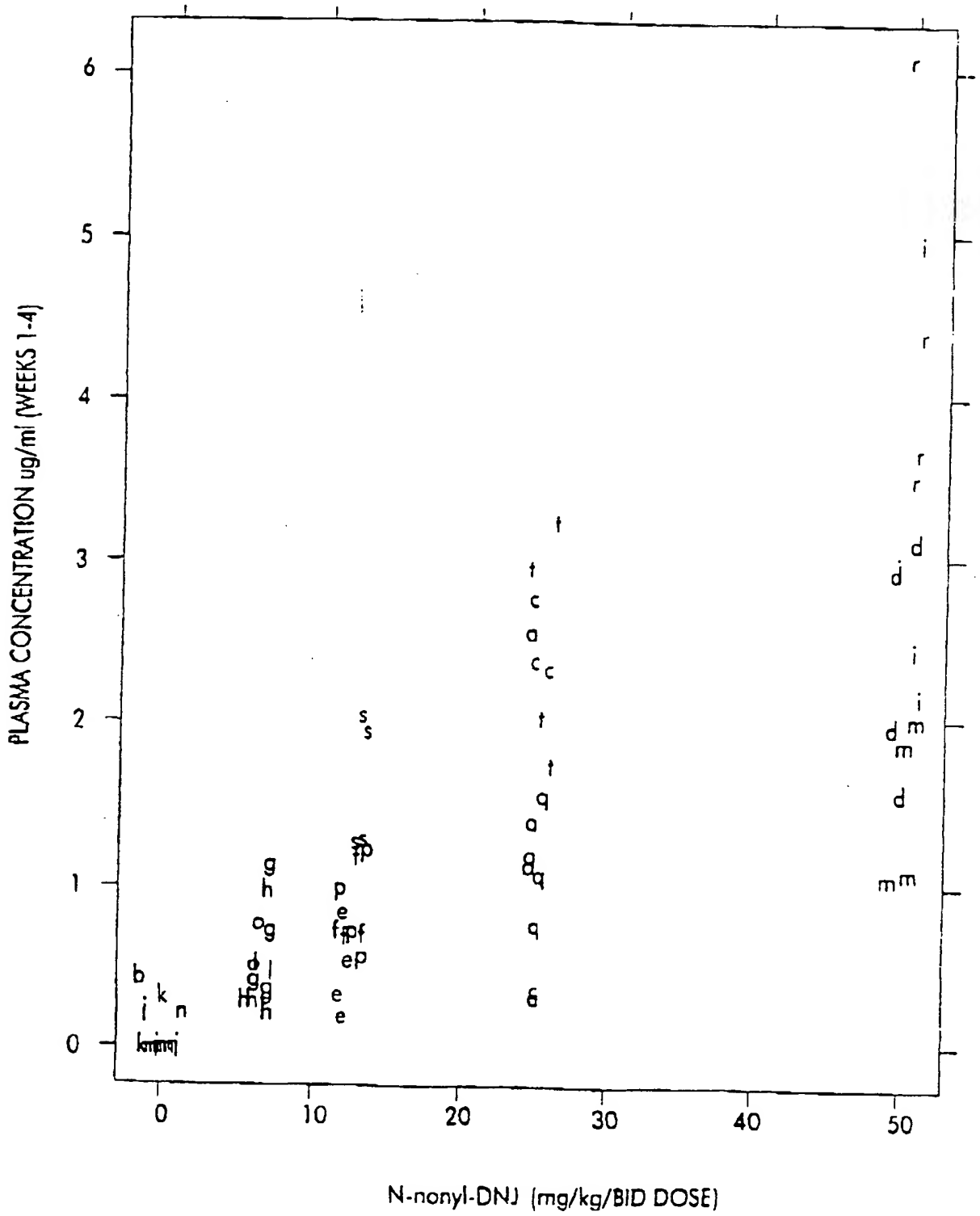
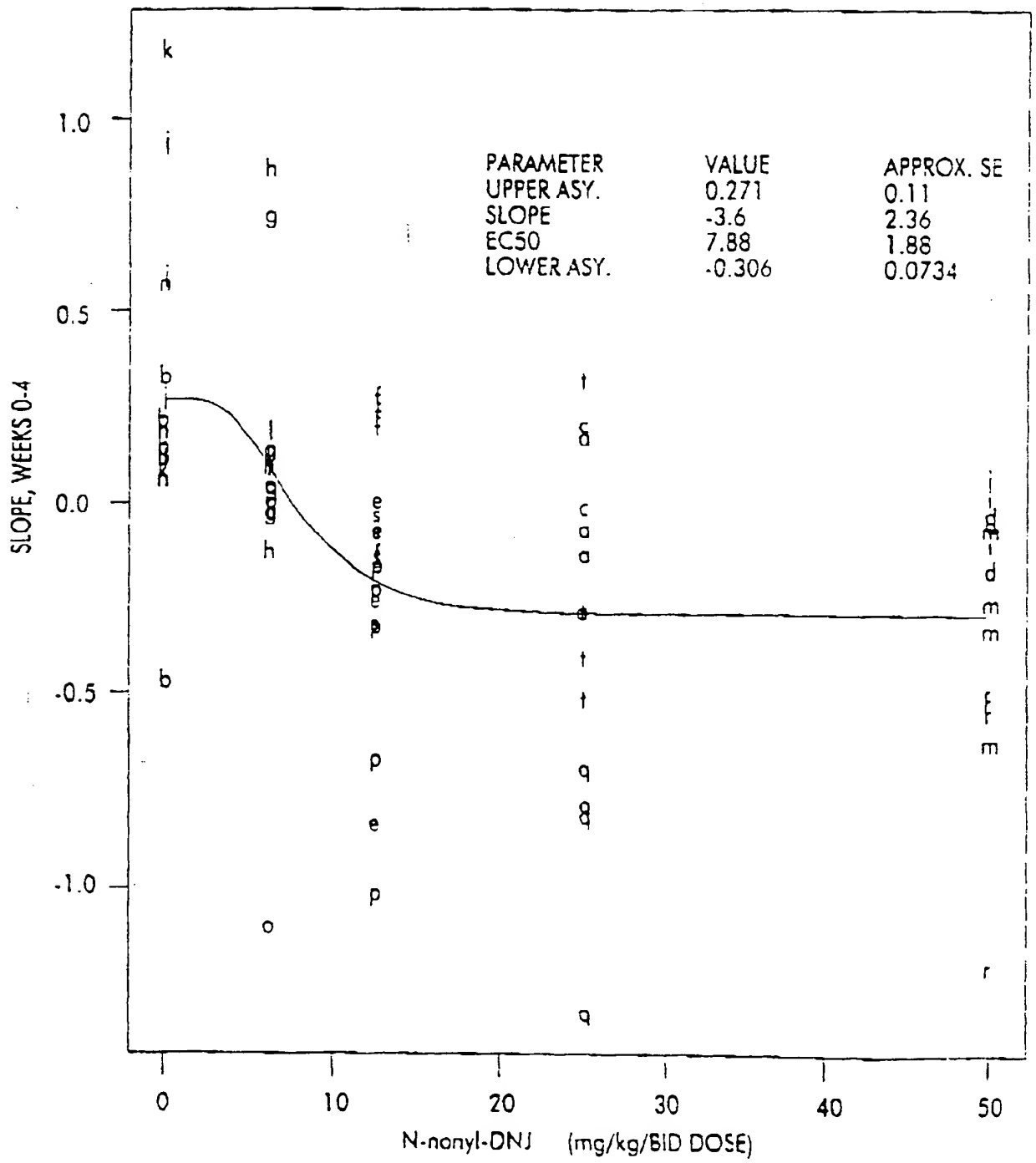


FIG.3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EC50 7.88 1.88
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SLOPE, WEEKS 0-4
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0.5
0.0
-0.5
-1.0
0
10
20
30
40
50
N-nonyl-DNJ (mg/kg/BID DOSE)

INTERNATIONAL SEARCH REPORT

Int tional Application No
PCT/US 99/01874

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A61K31/445

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category '	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	WO 98 35685 A (G. D. SEARLE AND CO.) 20 August 1998 see claims 1-69 see page 26, line 1 - line 17	1-16, 25-32, 41-59, 78-85, 110-150
X	WO 95 22975 A (G. D. SEARLE & CO) 31 August 1995 see claims 1-7	78-109
X	EP 0 350 012 A (MEIJI SEIKA KAISHA LTD ET AL) 10 January 1990 see claims 1-4	78-109
X	EP 0 449 026 A (BAYER AG) 2 October 1991 see the whole document	78-109

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

' Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

& document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 June 1999	09/06/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Siatou, E

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

In' ıtional Application No
PCT/US 99/01874

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 367 748 A (G. D. SEARLE & CO) 9 May 1990 see claims 1-9	78-109
Y	WO 95 19172 A (G. D. SEARLE ET AL) 20 July 1995 see claims 1-3	1-40, 60-77
Y	US 5 030 638 A (R. A. PARTIS ET AL) 9 July 1991 see the whole document	1-40, 60-77
A	PLATT F M ET AL: "N-BUTYLDEOXYNOJIRIMYCIN IS A NOVEL INHIBITOR OF GLYCOLIPID BIOSYNTHESIS. SECRETION OF HUMAN HEPATITIS B VIRUS IS INHIBITED BY THE IMINO SUGAR N-BUTYLDEOXYNOJIRIMYCIN" CHEMTRACTS ORGANIC CHEMISTRY, 1 January 1994, page 106/107 XP002067581 see the whole document	1-77
A	BLOCK T M ET AL: "THE SECRETION OF HUMAN HEPATITIS B VIRUS IS INHIBITED BY THE IMINO SUGAR, N-BUTYL-DEOXYNOJIRIMYCIN" ANTIVIRAL RESEARCH, vol. 23, no. SUPPL. 01, 1 January 1994, page 79 XP002067579 see the whole document	1-77

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 99/01874

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

Remark: Although claims 1-77 are directed to a method of treatment of the human/animal body, the search has been carried out and based on the alleged effects of the compound/composition.

2. [ ] Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

In' itional Application No
PCT/US 99/01874

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